

Chapter 10

Primary Lead Processing

The primary lead processing sector consists of five facilities that, as of September 1989, were active and reported generating a special mineral processing waste: slag from smelting and refining. One facility conducts only smelting, a second only refining, and the other three conduct both operations, as is shown in Exhibit 10-1. The bullion from the East Helena smelter is refined at the Omaha refinery, which also processes secondary materials.¹ The data included in this section are discussed in additional detail in a technical background document in the supporting public docket for this report.

Exhibit 10-1
Primary Lead Processing Facilities

Operator/Owner	Location	Type of Operation
ASARCO	East Helena, MT	Smelter
ASARCO	Glover, MO	Smelter and Refinery
ASARCO	Omaha, NE	Refinery
Doe Run/Fluor Corp. ^(a)	Boss, MO	Smelter and Refinery
Doe Run/Fluor Corp. ^(a)	Herculaneum, MO	Smelter and Refinery

^(a) Bureau of Mines, 1990. Personal communication with BOM Commodity Specialist, 27 June.

10.1 Industry Overview

The primary domestic use of lead is in lead-acid storage batteries. Lead is also used in containers and as an additive for gasoline, though these uses are rapidly declining.² Lead also is used to manufacture lead oxides which are used in the battery, glass, ceramics, rubber, and coatings industries.³

Three of the five facilities are located in Missouri, one is in Montana, and the other is in Nebraska. The dates of initial operation for these facilities range from 1879 to 1968. Four of the facilities were extensively modernized between 1967 and 1988; the fifth, the Boss, MO facility, which was new in 1968, reportedly has not undergone extensive modernization and is operating intermittently at less than 10 percent of capacity. The three ASARCO facilities have designated their aggregate annual lead refining production capacity, production, and capacity utilization data from the SWMPF Survey as confidential.⁴ The Bureau of Mines reports that the estimated production of refined lead from primary

¹ In addition to the five primary facilities, approximately 50 secondary processing facilities are operating; the operations conducted at these facilities, however, fall outside EPA's established definition of primary mineral processing and accordingly, do not generate special mineral processing wastes. (See 54 FR 36619-36620, September 1, 1989.)

² Bureau of Mines, 1987. Minerals Yearbook, 1987 Ed., p. 544.

³ Bureau of Mines, 1985. Mineral Facts and Problems, 1985 Ed., p. 439.

⁴ ASARCO and Doe Run, 1989. Company Responses to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

processing was 392,000 metric tons in 1988;⁵ in the SWMPF Survey, Doe Run reported its 1988 production from its Boss and Herculanum smelter/refineries as 10,000 and 225,000 metric tons, respectively.

The U.S. Bureau of Mines estimates that after a sharp decline between 1985 and 1986, the quantity of refined lead produced in the U.S. has slowly but steadily increased from 370,000 metric tons in 1986 to 395,000 metric tons in 1989. With the increasing production rate, the U.S. became a significant lead concentrate exporter in 1989. Recent expansion in the primary lead industry consists of a large new smelting and refining facility coming on-line in late 1989. In addition, mines in Alaska, Idaho, Missouri, and Montana were newly opened, re-opened, or expanded during the late 1980s.⁶

The Bureau estimates that primary smelter production will remain at about 400,000 metric tons in 1990. Domestic consumption of lead is expected to decline slightly in 1990, but, on a worldwide scale, this decrease in consumption is expected to be offset somewhat by increased demand in Asia and, to a lesser extent, in Europe.⁷ U.S. output of refined lead is expected to increase slightly in 1990, although this increase should be due entirely to secondary lead output.⁸ Future growth in the lead market depends highly upon the level of growth and new developments in the transportation, electrical, and electronics industries.⁹

The sector wide capacity of primary refined lead (i.e., the capacity of the ASARCO/East Helena smelter is not included because all product is sent to a separate refinery) is estimated to be 577,000 metric tons per year. Long-term capacity utilization (i.e., from 1990 to 1995), as reported by the Bureau of Mines, is expected to range from 100 percent at the Glover and Herculanum facilities to 80, 50, and 20 percent at the East Helena, Omaha, and Boss facilities, respectively.

Primary lead processing consists of both smelting (blast furnace and dross furnace operations) and refining operations, as shown in Exhibit 10-2. In the smelting process, sintered ore concentrate is introduced into a blast furnace along with coke, limestone, and other fluxing materials; the lead is reduced, and the resulting molten material separates into four layers: lead bullion (98 wt. percent lead); "speiss" and "matte," two distinct layers of material which contain recoverable concentrations of copper, zinc, and minor metals; and blast furnace slag.¹⁰ The speiss and matte are sold to copper smelters for recovery of copper and precious metals; the blast furnace slag is stored in piles and partially recycled (at the three Missouri facilities) or disposed (at the Montana facility). The lead bullion is then drossed (i.e., agitated in a drossing kettle and cooled to just above its freezing point) to remove lead and other metal oxides, which solidify and float on the molten lead bullion. The solidified material (referred to as dross), which is composed of roughly 90 percent lead oxide, along with copper, antimony, and other elements, is skimmed off the bullion and fed to a dross furnace for recovery of the non-lead mineral values. About 50-60 percent of the recovery furnace output is slag and residual lead that are both returned to the blast furnace. The remainder of the dross furnace output is sold to copper smelters for recovery of the copper and other precious metals. The lead bullion may also be decopperized before being sent to the refining plant.

Lead refining operations continue the process of removing various saleable metals (e.g., gold and silver, bismuth, zinc, and metal oxides such as antimony, arsenic, tin, and copper oxide). These operations, which are described in detail in the technical background document, are softening, desilverizing, dezincing, and bismuth removal. In the final refining step the lead bullion is mixed with fluxes to remove remaining impurities (e.g., calcium, magnesium, and lead oxide). Reagents (e.g., caustic soda and/or nitrates) may be

⁵ Bureau of Mines, 1990. Personal communication with BOM Commodity Specialist.

⁶ William D. Woodbury, 1990. U.S. Bureau of Mines, "Lead," Mineral Commodity Summaries, 1990 Ed., pp. 91, 96, 97.

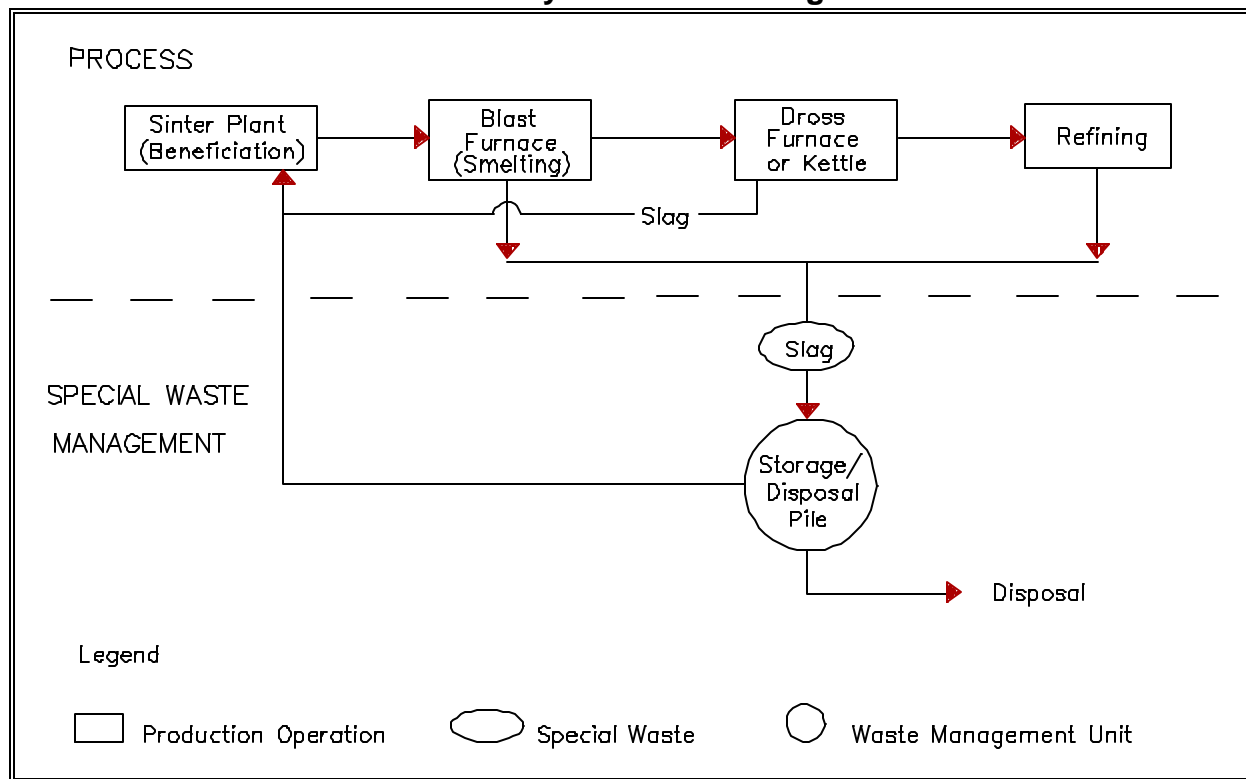
⁷ Alan S. Kafka, 1990. "Lead: Tight Market Possible; 121st Annual Survey and Outlook," E&MJ, March, p. 24.

⁸ Ibid., p. 23.

⁹ Ibid.

¹⁰ Environmental Protection Agency, 1984. Overview of Solid Waste Generation, Management, and Chemical Characteristics in the Primary Lead Smelting and Refining. Prepared by PEI Associates for U.S. EPA, Office of Research and Development, Washington, D.C., December.

Exhibit 10-2
Primary Lead Processing



added to the lead, which is then cooled, causing the impurities to rise to the surface and be removed. This refining residue is returned directly to the blast furnace at the Missouri facilities (the three integrated smelter/refinery operations) and, therefore, is not a solid waste at these facilities. The refinery "slag" generated at the stand-alone refinery in Nebraska is not recycled, but discarded as a solid waste. The refined lead is then cast into ingots.

10.2 Waste Characteristics, Generation, and Current Management Practices

The special mineral processing waste, slag, generated by primary production of lead is generated as a molten mass. The slag may be "hot-dumped" onto a waste pile to form large solid chunks or granulated with a water jet to form fine, sand-sized particles. As reported in the SWMPF Survey and indicated by EPA's sampling results, lead slag is composed primarily of iron and silicon oxides, as well as aluminum and calcium oxides. Other metals may also be present in smaller amounts, including antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, silver, and zinc.^{11,12}

Using available data on the composition of lead slag, EPA evaluated whether the slag exhibits any of the four characteristics of hazardous waste: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, EPA does not believe the slag is corrosive, reactive, or ignitable, but some slag samples do exhibit the characteristic of EP toxicity. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for lead slag from all five facilities of interest. Of these

¹¹ EPA, 1989. "National Survey of Solid Wastes from Mineral Processing Facilities."

¹² EPA, 1989. "Waste Sampling Data."

constituents, arsenic, cadmium, lead, mercury, and selenium concentrations were found to sometimes exceed the EP regulatory levels, with all five facilities having an exceedance for at least one of these constituents. Lead concentrations exceeded the EP level at every facility and in a total of 27 out of 101 samples; the maximum lead concentration exceeded the EP level by a factor of 19. Cadmium concentrations in 7 out of 99 samples (from two facilities) exceeded the EP level by as much as a factor of 8. Arsenic, mercury, and selenium concentrations exceeded the EP level at only one facility, ASARCO in Omaha, NE. However, arsenic and selenium exceeded the level in roughly 27 out of 94 samples from the Omaha facility by as much as a factor of 1,400 and 180, respectively. Mercury concentrations at the Omaha plant exceeded the level in 79 out of 94 samples by as much as a factor of 8. Two of the slag samples that failed the EP toxicity level for lead were also analyzed using the SPLP leach test, and for both of these samples, the concentration of lead measured using the SPLP test was at most 0.7 times the EP toxicity regulatory level.

Blast furnace slag is generated at four facilities; the fifth facility (Omaha, NE) generates waste slags from refining (e.g., exchange kettle and cupola furnace slag) in quantities about two orders of magnitude smaller than the other facilities (actual volume is confidential). For purposes of this report, as established during the reinterpretation rulemaking process, the slag generated at all five facilities, including Omaha's refinery slags, are considered slag from primary lead processing. Refinery slags at the three Missouri facilities, as well as slag from the smelters' dross furnaces, are not included in EPA's analyses, as these slags are directly recycled to the production process and are, therefore, not considered solid wastes.

Only one fully operational lead facility reported non-confidential waste generation data; Doe Run/Herculaneum reported generating 220,000 metric tons of slag in 1988, with a waste-to-product ratio of 0.97. EPA estimates the long term annual waste generation rate for the entire sector to be 469,000 metric tons per year. For the three fully operational facilities with smelter operations (i.e., one standby facility, Doe Run/Boss, and one stand-alone refinery, ASARCO/Omaha, are excluded), the annual generation rate is estimated to be 448,000 metric tons for an average of nearly 150,000 metric tons per facility and a waste-to-product ratio of 1.10. The refinery slag at Omaha is not recycled as is refinery slag at the integrated facilities and is, therefore, considered a waste; the estimated generation rate is 8,000 metric tons per year with a waste-to-product ratio of 0.11.

The predominant waste management practice used at the five lead facilities is to return a majority of the furnace slag (73 and 64 percent at the Doe Run facilities) to the sinter plant and stockpile the remainder. The East Helena smelting facility reported stockpiling all slag on-site; its Omaha refinery reported landfilling all slag off-site. Based on responses to the SWMPF Survey, the total volume of slag accumulated on-site for four lead smelting facilities is approximately 2.7 million metric tons; quantities range from 430,000 to 1,360,000 metric tons at the four smelters. (No slag reportedly accumulates at the Omaha refinery.)

The average dimensions of the slag piles at the four smelting facilities with on-site piles are 30,300 square meters (7.5 acres) of basal area and 10.5 meters (35 feet) of height; on a facility-specific basis the basal areas range from 20,200 to 48,500 square meters and the height from six to 18 meters. Three of the four smelter facilities with large slag piles report that these slag piles are lined with in-situ clay, the fourth is unlined. The Omaha refinery uses three small concrete-lined storage piles to hold slag before shipment off-site; the three piles range from 68 to 230 square meters in basal area and 1.5 to 3 meters in height.

Two facilities reported monitoring ground water around their slag piles, while a third reported monitoring only surface water. One facility reported having run-on/run-off controls; another facility reported using dust suppression but did not describe the practice; and a third facility reported that it collects and manages leachate from the slag pile.

10.3 Potential and Documented Danger to Human Health and the Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health or the environment has been proved. Overall conclusions about the hazards associated with lead slag are provided after these two study factors are discussed.

10.3.1 Risks Associated With Lead Slag

Any potential danger to human health and the environment from lead slag depends on the presence of toxic constituents in the slag that may pose a risk and the potential for exposure to these constituents. These factors are discussed separately below, followed by EPA's risk modeling results for lead slag.

Constituents of Concern

EPA identified chemical constituents in lead slag that may pose a risk by collecting data on the composition of lead slag and evaluating the intrinsic hazard of the slag's chemical constituents.

Data on Lead Slag and Leachate Composition

EPA's characterization of lead slag and its leachate is based on data from three sources: (1) a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW); (2) industry responses to a RCRA §3007 request in 1989; and (3) sampling and analysis conducted by EPA's Office of Research and Development (ORD) in 1984. These data provide information on the concentrations of some 20 metals, sulfate, and fluoride in total solids and leach test samples.

These sources provide data on the composition of slag solids at all but one of the five primary lead processing facilities (Boss, MO). Concentrations in total samples of the lead slag are generally within two orders of magnitude for most constituents across all data sources (i.e., EPA and RCRA §3007 responses) and facilities. A notable exception is that concentrations of antimony, arsenic, and silver for the Omaha facility are more than three or four orders of magnitude higher than concentrations of these constituents in slag from any of the other facilities. This difference probably occurs because the Omaha facility, which provided the data, is the only facility that generates refinery slag but no smelter slag.

Data from leach test analyses are available for all five facilities. With a few exceptions, concentrations from leach test analyses of the slag generally are within two orders of magnitude across the data sources (i.e., OSW, ORD, and industry), types of leach tests (EP, SPLP, and TCLP), and facilities.

Process for Identifying Constituents of Concern

As discussed in Section 2.2.2, the Agency evaluated the waste composition data summarized above to determine if lead slag contains any chemical constituents that may pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing constituent concentrations to conservative screening criteria and then by evaluating the environmental persistence and mobility of constituents that are present at levels above the criteria. These screening criteria were developed using assumed scenarios that are likely to overestimate the extent to which lead slag constituents are released to the environment and migrate to possible exposure points. For example, EPA evaluated the potential for chemicals to pose an inhalation risk by assuming that dust from the slag is blown into the air, when in fact the particle size of most slag is such that it would not become airborne. As a result, this process eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic ecosystems, and air and surface/ground-water resources (see Exhibit 2-3). Given the conservative (i.e., protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the waste in greater detail.

Identified Constituents of Potential Concern

Exhibits 10-3 and 10-4 summarize the frequency with which the chemical constituents of lead slag exceed the risk screening criteria. Data are provided in the exhibits for all constituents that are present in concentrations that exceed a screening criterion.

Exhibit 10-3 identifies constituents in lead slag that are present in concentrations that exceed the screening criteria based on the total sample analysis results from EPA and industry sampling. As shown, eight of the more than 20 constituents analyzed in the slag solids were detected in concentrations that exceed human health screening criteria: arsenic, cadmium, chromium, lead, selenium, antimony, silver, and zinc. All of these constituents are persistent in the environment (i.e., they do not degrade). Arsenic and lead exceeded the criteria most frequently and by the widest margins. For example, both of these constituents exceeded the screening criteria in roughly 90 percent or more of all samples analyzed from at least half of the facilities. Arsenic, lead, chromium, and antimony exceeded the screening criteria by more than a factor of 10 in at least one sample. These exceedances indicate the potential for two types of impacts, as follows:

- Arsenic, lead, antimony, silver, and zinc concentrations may cause adverse health effects if a small quantity of the slag or soil contaminated with the slag is inadvertently ingested over a long period of time, which could occur if public access to the slag piles is not restricted.

Exhibit 10-3
Potential Constituents of Concern in Lead Slag Solids^(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Human Health Screening Criteria ^(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Lead	153 / 153	Ingestion	153 / 153	4 / 4
Arsenic	13 / 15	Ingestion* Inhalation*	13 / 15 13 / 15	2 / 4 2 / 4
Antimony	16 / 19	Ingestion	14 / 19	2 / 4
Zinc	81 / 81	Ingestion	2 / 81	2 / 4
Cadmium	8 / 65	Inhalation*	4 / 65	1 / 3
Chromium	1 / 4	Inhalation*	1 / 4	1 / 3
Selenium	1 / 3	Inhalation	1 / 3	1 / 3
Silver	142 / 145	Ingestion	6 / 145	1 / 4

- (a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.
- (b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a 1×10^{-6} lifetime cancer risk; others are based on noncancer effects.

Exhibit 10-4
Potential Constituents of Concern in Lead Slag Leachate^(a)

Potential Constituents of Concern	No. of Times Constituent Detected/No. of Analyses for Constituent	Screening Criteria ^(b)	No. of Analyses Exceeding Criteria/ No. of Analyses for Constituent	No. of Facilities Exceeding Criteria/ No. of Facilities Analyzed for Constituent
Lead	101 / 101	Human Health Resource Damage Aquatic Ecological	72 / 101 94 / 101 61 / 101	5 / 5 5 / 5 5 / 5
Cadmium	97 / 99	Human Health Resource Damage Aquatic Ecological	14 / 99 17 / 99 17 / 99	5 / 5 5 / 5 5 / 5
Arsenic	87 / 96	Human Health* Resource Damage Aquatic Ecological	87 / 96 44 / 96 31 / 96	5 / 5 1 / 5 1 / 5
Zinc	16 / 16	Human Health Resource Damage Aquatic Ecological	5 / 16 5 / 16 13 / 16	3 / 4 3 / 4 4 / 4
Iron	12 / 14	Resource Damage Aquatic Ecological	7 / 14 2 / 14	4 / 4 2 / 4
Cobalt	2 / 3	Resource Damage	2 / 3	2 / 3
Copper	10 / 16	Aquatic Ecological	7 / 16	3 / 5
Manganese	14 / 14	Human Health Resource Damage Aquatic Ecological	1 / 14 8 / 14 1 / 14	1 / 4 4 / 4 1 / 4
Mercury	83 / 94	Human Health Resource Damage Aquatic Ecological	79 / 94 79 / 94 81 / 94	1 / 5 1 / 5 2 / 5
Selenium	79 / 93	Human Health Resource Damage Aquatic Ecological	25 / 92 46 / 92 26 / 92	1 / 5 1 / 5 1 / 5
Silver	79 / 94	Aquatic Ecological	9 / 94	1 / 5
Antimony	74 / 76	Human Health Aquatic Ecological	64 / 76 10 / 76	1 / 4 1 / 4

- (a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. Unless otherwise noted, the constituent concentrations used for this analysis are based on EP leach test results.
- (b) Human health screening criteria are based on cancer risk or noncancer health effects. "Human health" screening criteria noted with an "h" are based on a 1×10^{-5} lifetime cancer risk; others are based on noncancer effects.

- Selenium, arsenic, chromium, and cadmium may pose a health threat if slag dust is blown into the air and inhaled in a concentration that equals the National Ambient Air Quality Standard for particulate matter. However, as discussed in more detail in the section on Air Release, Transport, and Exposure Potential, the particle size distribution of lead slag and the distance to potential receptors significantly limits the potential for such large exposures to dust from slag piles.

Lead concentrations in 26 of 153 samples of the slag solids (from two of four facilities) also exceeded the air resource damage screening criterion. This suggests that lead concentrations could be high enough to cause an exceedance of the National Ambient Air Quality Standard for lead if slag dust is blown into the air in a concentration that equals the air quality standard for particulates matter. Again, the extent to which dust is actually blown into the air from slag piles is limited by the relatively large size of lead slag particles.

Exhibit 10-4 identifies the constituents that exceed the screening criteria based on leach test data from EPA and industry.¹³ As shown, 12 constituents were detected in lead slag leachate in concentrations that exceed risk screening criteria for water-based release and exposure pathways. All of these constituents are inorganics that do not degrade in the environment. In general, arsenic, lead, and mercury exceeded the criteria most frequently (in at least 90 percent of the samples from at least half of the facilities). The arsenic and lead concentrations also exceeded the screening criteria by the widest margins (up to a factor of 1,000 or more). As discussed previously, arsenic, lead, cadmium, mercury, and selenium were also measured in EP leachate in concentrations that exceeded the EP toxicity regulatory levels.

These exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- Arsenic, cadmium, lead, selenium, antimony, zinc, and mercury concentrations in the slag leachate may pose a health risk if the leachate is released to ground water, diluted by a factor of 10 during migration to a downgradient drinking water well, and ingested over a long period of time.
- If the slag leachate is released to ground or surface water, arsenic, cadmium, lead, selenium, cobalt, iron, manganese, zinc, and mercury concentrations could render the water unsuitable for a variety of uses (e.g., irrigation, direct human consumption of the water, or human consumption of fish that live in affected water bodies).
- Concentrations of arsenic, cadmium, lead, selenium, antimony, silver, copper, iron, zinc, and mercury in the slag leachate may present a threat to aquatic organisms if the leachate migrates (with a 100-fold dilution) to surface waters.

These exceedances, by themselves, do not prove that the slag poses a significant risk, but rather indicate that the slag may present a hazard under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for this waste to cause significant impacts, EPA proceeded to the next step of the risk assessment to analyze the actual conditions that exist at the facilities that generate and manage the slag.

Release, Transport, and Exposure Potential

This analysis evaluates the baseline hazards of lead slag as it was generated and managed at the five active facilities in 1988. Lead slag is primarily disposed on-site (i.e., at four of five facilities) and the slag is not currently used off-site, although several options for off-site utilization are available (see Section 10.5). This analysis does not assess the hazards of off-site disposal of slag from the Omaha facility because of a lack of data on the management practices and environmental conditions of the off-site disposal facility. Instead, this analysis evaluates hazards posed by the storage of slag at the Omaha facility prior to its transport off-site. The following analysis also does not consider the risks

¹³ For the purpose of this analysis, comparison of leach test data to screening criteria rely on EP leach test results. Results from the SPLP leach test identified the same constituents of concern as the EP leach test, though the results from the two leach tests differ somewhat in terms of the magnitude with which constituent concentrations exceed the screening criteria.

associated with variations in waste management practices or potentially exposed populations in the future because of a lack of data adequate to predict future conditions.

Ground-Water Release, Transport, and Exposure Potential

As discussed in the preceding section, EPA and industry test data show that several constituents are capable of leaching from lead slag in concentrations above the screening criteria. However, considering the existing slag management practices and neutral pH conditions that are expected, only arsenic, cadmium, selenium, cobalt, and mercury are likely to be mobile in ground water if released. Exhibit 10-5 summarizes the key factors at each lead facility that affect the potential for these constituents to be released into ground water and cause impacts through that pathway.

Releases to ground water at the East Helena, MT smelter, the Glover, MO facility, and the Boss, MO facility are considered possible because ground-water monitoring near the slag piles at each of these sites has identified contamination that may be attributable to the slag. (See the damage case study findings in Section 10.3.2 for more discussion of this observed contamination.) The releases at Glover and Boss may have been facilitated by the karst and dolomite that underlie these sites. These earth materials are prone to develop solution cavities that can permit the ready transport of ground-water contaminants. The East Helena facility is in an area that has a very low natural net recharge to ground water, less than 1 cm/yr. However, any ground-water contamination that can be attributed to the slag pile at this site could have been caused by the former practice of sprinkling contaminated wastewater on the pile to control dust. There are also wastewater ponds near the slag pile at East Helena that appear to be primary contributors to ground-water contamination at this site. Ground water in the vicinity of each plant is used as a drinking water supply, and residences that could have drinking water wells are located only 180 meters downgradient from the East Helena smelter and 980 meters downgradient of the Boss facility. The distance between the slag pile at Glover and the nearest downgradient residence that could have a well is not known, but the nearest property boundary in a downgradient direction (where the ground water conceivably could be withdrawn for drinking) appears to be at least 600 meters from the pile.

Although ground-water monitoring data are not available for the Herculaneum facility and the Omaha refinery, the potential for releases to ground water and subsequent exposures at these sites is reduced by a number of site-specific factors.

- The on-site slag pile at the Herculaneum facility is underlain by in-situ clay. The uppermost useable aquifer is deep, roughly 80 meters below the land surface, and the primary earth materials separating the slag pile from this useable aquifer are relatively impermeable clays and silts. The net recharge in the area of the Herculaneum facility is very low, about 2 cm/yr, meaning that relatively little precipitation is available to seep through the pile and carry slag contaminants to the subsurface. Ground water in the area is used as a municipal drinking water supply, but there currently are no downgradient drinking water wells within 1,600 meters (1 mile).
- Ground water beneath the Omaha refinery is very shallow, only 2 meters beneath the land surface. However, release from the three, relatively small slag piles to ground water is limited by management practices (i.e., use of concrete pits for slag storage) and a low net recharge (5 cm/yr). There are no known uses of ground water in the area, and there are no downgradient drinking water wells within 1,600 meters (1 mile) of the site.

If leachate from the slag piles at the Herculaneum and Omaha facilities did seep into ground water, it could restrict potential ground-water uses in the future, but it would not pose a current health threat considering the large distances to existing drinking water wells.

Exhibit 10-5 Summary of Release, Transport, and Exposure Potential for Lead Slag

Facility	Release, Transport, and Exposure Potential	Proximity to Sensitive Environments
BOSS	<p>Ground Water: Releases limited by in-situ clay liner, leachate collection system, large depth to useable aquifer (45 m), impermeable subsurface, and low net recharge (5 cm/yr); contamination that may be attributable to the slag pile has been detected, although this contamination may have been caused by two unlined wastewater impoundments next to the pile; nearest downgradient drinking water well is 980 meters away.</p> <p>Surface Water: High annual precipitation (98 cm), impermeable subsurface, and steeply sloped land (6-12%) create the potential for surface erosion; run-off from the slag pile, however, is collected and treated; Crooked Creek is located 1,100 m away; no consumptive uses of creek within 24 km, but low flow (16 mgd) indicates little potential for dilution and possible aquatic ecological risks.</p> <p>Air: Releases not controlled by dust suppression; wind erosion and dumping operations could lead to potential inhalation exposures at the nearest residences located 915 m from facility; 1,800 people living within 8 km (5 miles).</p>	Located in a National Forest
HERCULANEUM	<p>Ground Water: Releases limited by in-situ clay liner, large depth to useable aquifer (80 m), impermeable subsurface, and low net recharge (2 cm/yr); no drinking water wells within 1.6 km (1 mile) downgradient.</p> <p>Surface Water: High annual precipitation (94 cm), impermeable subsurface, and moderate topographic slope (up to 6%) create potential for surface erosion; Mississippi River is close (within 90 m), but its very large flow (100,000 mgd) yields significant dilution; no consumptive uses of river within 24 km.</p> <p>Air: Releases not controlled by dust suppression; wind erosion and slag dumping could lead to airborne dust and inhalation exposures at the nearest residence just 15 m from facility; 25,000 people living within 8 km (5 miles).</p>	Located in a 100-year floodplain and within 1.6 km of a wetland
EAST HELENA	<p>Ground Water: Pile is not lined, useable aquifer is shallow (4 m deep), and subsurface is permeable; although net recharge is slow (< 1 cm/yr), former practice of sprinkling pile with wastewater for dust suppression may have led to ground-water contamination; observed contamination is mainly attributed to two unlined impoundments, not the slag pile; potential drinking water exposure at residence as close as 180 m downgradient.</p> <p>Surface Water: Surface erosion limited by low annual precipitation (29 cm) and gentle topographic slope (< 2%); Prickly Pear Creek located just 55 m downgradient; although no consumptive uses of creek within 24 km, the creek's slow flow (26 mgd) allows little dilution and possible aquatic ecological risks.</p> <p>Air: Releases not controlled by dust suppression, and monitoring has detected exceedance of air quality standard for lead; potential inhalation exposures at residences located as close as 180 m from facility and potential food chain exposure through deposition of particulate matter on surrounding agricultural fields; approximately 12,000 people living within 8 km (5 miles).</p>	Located in a 100-year floodplain, a wetland, and a fault zone

Exhibit 10-5 (cont'd)
Summary of Release, Transport, and Exposure Potential
for Lead Slag

Facility	Release, Transport, and Exposure Potential	Proximity to Sensitive Environments
OMAHA	<p>Ground Water: Although ground water shallow (2 m deep), releases limited by concrete liners and low net recharge (5 cm/yr); no drinking water wells within 1.6 km (1 mile) downgradient.</p> <p>Surface Water: Moderate annual precipitation (76 cm), low net recharge, moderate topographic slope (up to 6%), and short distance to Missouri River (60 m) create surface water contamination potential; however, river's large flow (18,000 mgd) provides for significant dilution and there are no consumptive uses within 24 km.</p> <p>Air: Releases controlled by dust suppression, decreasing release potential; if airborne releases, potential inhalation exposures at residences located as close as 1,100 m from facility; roughly 224,000 people living within 8 km (5 miles).</p>	Located in a 100-year floodplain and a fault zone, and within 1.6 km of a wetland
GLOVER	<p>Ground Water: Although releases limited by in-situ clay liner, stormwater run-on/run-off controls, impermeable subsurface, and low net recharge, monitoring has identified ground-water contamination; ground water is used for drinking in the area, but the nearest property boundary in downgradient direction (where water could be withdrawn) is 600 m from slag pile.</p> <p>Surface Water: Existing ground-water contamination, high annual precipitation (105 cm) and moderate distance to Scroggins Branch that discharges into Big Creek (244 m) create contamination potential; however, run-off from the slag pile is now collected and treated prior to discharge; creek not used for consumptive uses within 24 km, but its moderate flow (80 mgd) allows only moderate dilution and possible aquatic ecological risks; monitoring has identified contamination possibly attributable to slag pile.</p> <p>Air: Releases not controlled by dust suppression; wind erosion and slag dumping could lead to airborne dust and inhalation exposures at residences as close as 60 m from facility; only 840 people live within 8 km (5 miles).</p>	Located in a National Forest and an area of karst terrane

Surface Water Release, Transport, and Exposure Potential

The primary pathways for lead slag contaminants to enter surface waters are migration in a leached form through ground water that discharges to surface water, and direct overland run-off via storm water erosion either in a leached form or in the form of solid particles. The high concentrations of several constituents detected in slag leachate tests confirm that the potential exists for slag contaminants to migrate into surface water in a leached form. The physical form of the slag, however, being relatively large particles ranging from sand-size (0.2 to 2 mm) to boulders (larger than 0.3 meters or 12 inches), should help limit the overland run-off of slag solids. Only particles that are 0.1 mm or less in size tend to be appreciably erodible, and only a very small fraction of the slag solids are expected to be in this size range.

Exhibit 10-5 summarizes the characteristics of each of the five lead facilities that affect the surface water release, transport, and exposure potential of lead slag. Based on an analysis of these characteristics, it is possible for slag contaminants to be released to surface water at all five facilities. In fact, an inspection report indicates that the slag pile at the Boss facility may be a source of surface water contamination and contaminated run-off that may discharge into surface water has been observed at the Glover and East Helena facilities (see the damage case study findings discussion below). All of the slag piles are located within 1,100 meters of a river or creek, with Herculaneum, East Helena, and Omaha

being within 100 meters of a water body. The Herculaneum, East Helena, and Glover facilities are also within 100-year floodplains, and although remote, the possibility of large releases from the slag piles caused by floods at these sites cannot be dismissed. In addition, all but the East Helena smelter are located in areas with relatively high annual precipitation (76 to 105 cm/yr) that could cause significant run-off. The only facilities that use storm water run-on/run-off controls at their slag piles are the Boss and Glover facilities.

Although there appears to be a potential for release at all lead facilities, the potential for significant surface water contamination appears to be greatest at the Boss, East Helena, and Glover facilities (depending on the efficiency of the storm water run-on/run-off controls at Boss and Glover). The creeks/rivers near these facilities are relatively small to moderate in size, with an average annual flow that ranges from 16 to 81 mgd. These relatively low flows provide a limited dilution capacity compared to that provided by rivers near Herculaneum and Omaha, which have an average annual flow of 100,000 mgd and 18,000 mgd, respectively. These large flows should allow for significant dilution of any contamination released from the slag piles. Furthermore, none of the creeks or rivers located near the lead facilities are currently used for drinking water or any other consumptive purpose within 24 km (15 miles). Therefore, any contamination originating from the slag piles would not pose a current health risk through surface water, though it could pose an aquatic ecological risk and render the water less suitable for potential future uses.

Air Release, Transport, and Exposure Potential

Because the constituents that exceed the screening criteria are nonvolatile, lead slag contaminants can only be released to air in the form of dust particles. The particles can be either blown into the air by wind or suspended in air by slag dumping and loading operations. Factors that affect the potential for such airborne releases include the particle size of lead slag, the height and exposed surface area of the slag piles, the slag moisture content, the use of dust suppression controls, and local wind speeds. The potential for exposure to airborne dust depends on the proximity of the slag piles to people and agricultural lands.

The relatively large size of lead slag particles limits the potential for release of airborne dust. In general, particles that are $\leq 100 \mu\text{m}$ (0.1 mm) in diameter are wind suspendable and transportable. Within this range, however, only particles that are $\leq 30 \mu\text{m}$ in diameter can be transported for considerable distances downwind, and only particles that are $\leq 10 \mu\text{m}$ in diameter are respirable. As mentioned previously, lead slag particles range from sand-size (0.2 to 2 mm) to boulders (larger than 30 cm). Therefore, the vast majority of the slag should not be suspendable, transportable, or respirable. It is likely that only a very small fraction of the slag will be weathered and aged into smaller particles that can be suspended in air and cause airborne exposure and related impacts.

The height and exposed area of the slag piles, the slag moisture content, the use of dust suppression controls, wind speeds, and the proximity of the slag pile to people vary on a site-specific basis, as follows:

- At the Boss facility, the slag pile is approximately 20,000 square meters (5 acres) in area and 6 m high. The pile is not covered with either vegetation or a synthetic material. The facility does not use any dust suppression controls, such as sprinkling water on the pile, and the number of days with rain, which may suppress dust, is small (73 days/yr). As a result, the surface slag is expected to be dry most of the time. Although short term gusts of strong winds inevitably occur, average wind speeds range from 2.3 to 4 m/s, which are strong enough to produce wind erosion of any fine particles on the surface of the slag pile. The nearest residence in a predominant wind direction is approximately 915 meters away and there are roughly 1,800 people living within 8 km (5 miles).
- The slag pile at the Herculaneum facility covers an area of 49,000 square meters (12 acres), is 8 m high, and is uncovered. The slag is expected to be dry most of the time because no dust suppression sprinkling is conducted and the number of days with precipitation is small (85 days/yr). Average wind speeds range from 3.6 to 5.5 m/s, although there are short-term gusts of stronger winds. The nearest residence is very close, only 15 meters downwind, and the surrounding population within 8 km is large, approximately 25,000 people.
- The slag pile at the East Helena facility covers an area of 20,000 square meters (5 acres), is 11 meters high, and is uncovered. Although the pile is not currently watered for the purpose of

dust suppression, there is a relatively large number of days that have a small amount of precipitation (155 days/yr) that should help keep the slag moist part of the time. Average wind speeds range from 2.3 to 4.7 m/s, although stronger winds occur on a short term basis. Ambient air quality monitoring in the vicinity of the pile has identified an exceedance of the air quality standard for lead, and plant personnel have indicated that the slag pile is a contributor to this contamination. The nearest residences are located 180 meters downwind and there are roughly 12,000 people that live within 8 km (5 miles). In addition, there is a potential for food chain exposures caused by the deposition of airborne particulates on agricultural fields that are near the facility.

- At the Omaha facility, there are three relatively small slag piles that are all less than 3 m high and cover a combined area of less than 12,000 square meters (3 acres). Although there is a small number of days of precipitation to help keep dust down (98 days/yr), the facility practices dust suppression. The nearest residence in a predominant wind direction is located 1,100 meters downwind. The plant is located in a densely populated area, with approximately 224,000 people living within 8 km.
- The slag pile at Glover covers 32,000 square meters (8 acres), is 18 m high, and is uncovered. The slag is expected to be dry most of the time because no dust suppression sprinkling is conducted and the number of days with precipitation is small (80 days/yr). Considering the average wind speeds (2.6 to 4.4 m/s) and the potential for short-term gusts of stronger winds, wind erosion is possible. Although the nearest residence in a predominant wind direction is only 60 meters downwind, the plant is located in a sparsely populated area: 840 people live within 8 km.

In summary, slag particles are generally quite large and only a very small fraction of the lead slag has the potential to be suspended in air and transported to downwind exposure points at each of the lead facilities. The slag piles, however, are generally large, tall, and uncovered, presenting a large exposed area from which dust can escape. Wind speeds in the vicinity of each facility are sufficient to cause windblown dust, and dust may also be suspended at each site by slag loading and unloading. The slag also is expected to be dry most of the time, which facilitates dusting. In addition, all five facilities have individuals living within 1.6 km (one mile) that could be exposed to airborne particles released from the slag piles.

Based on the evaluation of the lead slag composition presented above, constituents that could pose a health threat by dust inhalation include arsenic, cadmium, chromium, and selenium. The particle size distribution of lead slag, however, significantly limits the potential for constituent entrainment and transport to potential receptors. Among the five primary lead facilities, the potential for exposure to airborne contaminants appears greatest at the Herculaneum facility because of the close proximity to residences. The potential for airborne exposures appears lowest at Omaha because of the relatively small size of the slag piles and the dust suppression controls reportedly used at that site.

Proximity to Sensitive Environments

As summarized in Exhibit 10-5, all of the lead facilities are located in either a vulnerable environment or an environment that has high resource value. In particular:

- The Boss and Glover facilities are located in the Mark Twain National Forest in the Missouri Ozarks. The existing contamination that is potentially attributable to lead slag at these sites could make the forest less desirable to use for recreational purposes.
- The Herculaneum, East Helena, and Glover facilities are all located in 100-year floodplains, which creates the potential for large, episodic releases from the on-site slag piles due to flood events.
- The Herculaneum, East Helena, and Glover facilities are also located either in or within 1.6 km (one mile) of a wetland (defined here to include swamps, marshes, bogs, and other similar areas). Wetlands are commonly entitled to special protection because they provide habitats for many forms of wildlife, purify natural waters, provide flood and storm damage protection, and afford a number of other benefits.

- The East Helena and Glover facilities are located in fault zones. This creates the potential for earthquake damage to containment systems for slag piles at these sites.
- The Glover facility is located in an area of karst terrane, characterized by sink holes and underground cavities developed by the action of water in soluble rock (such as limestone or dolomite). Solution cavities that may exist in the bedrock at this site could permit any ground-water contamination originating from the slag pile to migrate in a largely unattenuated and undiluted fashion.

Risk Modeling

Based on the preceding analysis of the intrinsic hazard of lead slag and the potential for slag contaminants to be released into the environment, the Agency ranked lead slag as having a relatively high potential to cause risk to human health and the environment (compared to the other mineral processing wastes studied in this report). Therefore, EPA used the model "Multimedia Soils" (MMSOILS) to quantify the risks associated with the lead slag contaminants, facilities, and release and exposure pathways that appear to pose the greatest concern.

Ground-Water Risks

EPA modeled potential releases to ground water from the on-site slag piles at all five facilities of interest. Using site-specific data with respect to contaminant concentrations, slag quantities, existing management practices, and hydrogeologic characteristics, the Agency predicted the concentrations of arsenic, cadmium, selenium, cobalt, mercury, and lead in ground water at the following locations downgradient from the slag piles: the property boundary, the nearest existing residence that could have a private drinking water well, the nearest surface water body, and, to provide a common frame of reference across the facilities, the distances of 50, 500, and/or 1,000 meters downgradient. EPA used median constituent concentrations measured with the EP leach test as inputs to the model. For each constituent, the Agency compared the predicted concentrations at the modeled locations to EPA-approved benchmarks for human health protection, drinking water maximum contaminant levels (MCLs), and National Academy of Sciences (NAS) recommended guidelines for irrigation and livestock waters.

At the facilities in Boss, MO, Herculaneum, MO, and Omaha, NE, the predicted contaminant concentrations at each downgradient distance were two orders of magnitude or more below the various criteria. The predicted concentrations of arsenic at each of the downgradient locations were so small that, if the water was ingested, it would pose a lifetime cancer risk of less than 1×10^{-10} (i.e., the chance of getting cancer would be less than one in ten billion over a 70-year lifetime). In many cases, it was predicted that the contaminants would not migrate to the water table within the modeling horizon (200 years). Due to the low levels of precipitation infiltrating through the piles and into ground water, the depths to ground water, the low permeability of the underlying earth materials, and the tendency of the contaminants to bind to soil, many of the contaminants were predicted to remain adsorbed in the unsaturated zone at these sites for more than 200 years.

The same overall results were predicted for the facilities in Glover, MO and East Helena, MT, with the following exceptions:

- At the Glover facility, predicted concentrations of arsenic in ground water as far as 125 meters from the slag pile, but still on plant property, could pose a lifetime cancer risk of 4×10^{-7} . Predicted arsenic concentrations at the plant boundary (estimated to be about 600 meters downgradient) would yield cancer risks of less than 1×10^{-10} . EPA has assumed here that the slag pile and adjacent areas in the downgradient direction are not underlain by karst. If, however, the subsurface of these areas do contain karst, actual ground-water contaminant concentrations could be higher than EPA's risk modeling exercise has indicated.
- Also at the Glover facility, the predicted concentrations of cobalt in ground water roughly 250 meters downgradient from the slag pile exceeded the NAS irrigation guideline by as much as a factor of 7. Cobalt concentrations at the plant boundary and beyond were estimated to be below this threshold. If water with cobalt concentrations in excess of the NAS guideline is used continuously for irrigation, it could be toxic to tomatoes, peas, beans, oats, rye, wheat, barley, and corn.
- Similarly, at the smelter in East Helena, MT, the predicted concentrations of cobalt in ground water exceeded the NAS irrigation guideline by as much as a factor of 1.5 as far downgradient as the property boundary (about 55 meters from the slag pile).

This cobalt contamination at the Glover and East Helena facilities is likely to have little practical significance at present. Along with the fact that the contamination at Glover is likely to be confined to the plant property, the land surrounding the Glover facility is largely forested and does not appear to be used for agricultural purposes close to the site. Although the land surrounding the East Helena smelter is used for agriculture, a portion of the slag pile is adjacent to Prickly Pear Creek and any cobalt contamination in the ground water may discharge into the creek and be diluted somewhat, rather than extracted directly from the ground and used for irrigation.

Surface Water Risks

To evaluate surface water risks, EPA estimated the concentrations of lead slag contaminants in nearby rivers and creeks after the contaminants have been fully mixed in the water's flow. EPA considered in this analysis the annual (chronic) loading of contaminants to rivers/creeks via ground-water seepage and erosion from the slag piles, but did not consider larger short-term releases, such as those associated with large storms, that could result in higher concentrations that last for shorter durations. The Agency predicted the surface water concentrations of the following lead slag constituents: antimony, arsenic, cadmium, cobalt, iron, lead, manganese, mercury, selenium, silver, and zinc. For each constituent, the Agency compared the predicted concentrations to available EPA-approved benchmarks for human health protection, drinking water MCLs, freshwater ambient water quality criteria (AWQCs) for chronic exposures, and NAS recommended guidelines for irrigation and livestock waters. Note that the methodology used here does not account for removal of pollutants via drinking water treatment, and thus overstates risk through this pathway. In addition, the Agency conservatively modeled the slag piles at the Boss and Glover facilities as if they were not equipped with stormwater run-on/run-off controls.

For the facilities located in Herculaneum, MO and Omaha, NE, the predicted concentrations of all contaminants were at least two orders of magnitude below the various criteria. The very large flows of the Mississippi and Missouri Rivers adjacent to these facilities were predicted to effectively dilute any contaminants released from the on-site slag piles.

The surface water concentrations of most contaminants were also estimated to be one or two orders of magnitude below the various criteria in the creeks near the Boss, East Helena, and Glover facilities. However, the predicted concentrations of arsenic, lead, iron, manganese, and zinc exceeded at least one criterion at each of these facilities. Essentially all of this contamination was estimated to be caused by erosion of fine particles from the slag piles, rather than seepage of contaminants into ground water that discharges into surface water. As shown in Exhibit 10-6:

- Estimated arsenic concentrations in the creeks nearest to the Boss, East Helena, and Glover facilities would cause lifetime cancer risks of 1×10^{-5} to 5×10^{-5} if ingested (i.e., the chance of

getting cancer would be at least one in 100,000 over a 70-year lifetime). These concentrations are well below the MCL, however.

- The estimated concentrations of lead in Crooked Creek near the Boss facility and Big Creek near the Glover facility exceed the noncancer effect threshold by roughly a factor of three. Long-term ingestion of water with this lead concentration could cause neurotoxicological effects.
- The estimated concentrations of iron, lead, and manganese in the creeks near the Boss and Glover facilities also exceed the drinking water MCLs for these constituents. In addition to the adverse neurotoxicologic effects of lead, such concentrations of iron and manganese could cause objectionable tastes and cause stains.
- The estimated concentration of lead in the creeks near all three facilities and the estimated concentration of zinc in the creeks near the Boss and Glover facilities exceed the AWQC for these constituents. Chronic exposures to these contaminant concentrations could adversely affect the health of any aquatic organisms living in the creeks. Depending on the efficiency of the stormwater run-on/run-off controls at the Boss and Glover facilities, the slag piles at these sites are likely to cause significantly less contamination than was predicted.

Of the constituents that were modeled, only mercury and selenium are recognized as having the potential to biomagnify (concentrate in the tissues of organisms higher in the food chain). EPA's predicted concentrations of mercury, however, were well below the AWQC and adverse effects due to biomagnification are not expected. Although the selenium concentrations were also predicted to be below the AWQC, the potential for selenium to biomagnify and cause adverse effects to wildlife at higher trophic levels cannot be ruled out (the selenium AWQC does not account for biomagnification). Mercury, cadmium, selenium, zinc, and, to a lesser extent, arsenic may bioaccumulate in the tissue of freshwater fish that may be ingested by humans. However, even if an individual ingests 6.5 grams of fish¹⁴ from the contaminated water every day of the year for 70 years, cancer risks would be less than 7×10^{-7} and the doses of noncarcinogens would be below adverse effect thresholds.

As discussed in the preceding section on potential release, transport, and exposure pathways, none of the creeks near the Boss, East Helena, and Glover facilities are currently used as drinking water supplies within 24 km of the sites. Therefore, the predicted contaminant concentrations in these creeks are not expected to pose a current drinking water threat, but may present a hazard if the waters are ever used for drinking in the future.

Air Risks

EPA modeled the release and inhalation of windblown dust from the slag piles at four of the five facilities: Glover, East Helena, Boss, and Herculaneum. At each facility, the Agency predicted risks caused by windblown arsenic, cadmium, chromium, selenium, and lead, which are the primary slag constituents that exceed the screening criteria through the air pathway based on the preceding analysis of the slag's composition. The Agency did not predict air pathway risks at the Omaha facility because that facility suppresses dust from the on-site slag piles. In general, the Agency's modeling approach was very conservative (i.e., tending to overpredict air pathway risks) because it was based on the assumption that there is an unlimited reservoir of fine particles that can be blown into the air from lead slag piles. As discussed

¹⁴ This is a typical daily fish intake averaged over a year (EPA, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December 1989).

Exhibit 10-6 Surface Water Risk Estimates for Lead Slag^(a)

Parameter/Constituent	Facility Location ^(b)		
	Boss, MO	East Helena, MT	Glover, MO
Distance to water	1,097 m	55 m	244 m
Cancer Risk			
Arsenic	5×10^{-5}	1×10^{-5}	1×10^{-5}
Ratio of Concentration to Noncancer Threshold			
Lead	2.9	0.2	2.6
Ratio of Concentration to MCLs^(c)			
Iron	2.1	0.3	1.8
Lead	12.4	0.7	11.2
Manganese	1.8	0.1	1.5
Ratio of Concentration to AWQCs^(d)			
Lead	19.3	1.1	17.5
Zinc	3.8	0.5	3.3

- (a) Values in this exhibit are based on constituent concentrations after complete mixing in the receiving waterbody. Results are provided for only those constituents that were predicted to exceed a criterion. The predicted concentrations of all other constituents that were modeled (cadmium, cobalt, mercury, selenium, silver, and antimony) were one to two orders of magnitude below the criteria.
- (b) The predicted surface water concentrations of all constituents that were modeled were at least two orders of magnitude below the criteria at the facilities in Herculaneum, MO and Omaha, NE. EPA conservatively modeled the slag piles at the Boss and Glover facilities as if they were not equipped with stormwater run-on/run-off controls. Depending on the efficiency of these control systems, the slag piles at these sites are likely to cause significantly less contamination than was predicted.
- (c) The proposed revised primary maximum contaminant level for lead, and the secondary maximum contaminant levels for iron and manganese.
- (d) The freshwater ambient water quality criteria for chronic exposures, designed to protect the health of aquatic organisms.

previously, lead slag actually has limited wind erosion potential, as it consists of a mixture of small particles and large chunks that consume much of the wind's shear stress.

Even with this conservative approach, risks caused by the inhalation of dust from lead slag piles were predicted to be very low at all four facilities. In particular, at the nearest residences in predominant wind directions (the maximum exposed individual) at each site:¹⁵

- The total lifetime cancer risk caused by the inhalation of arsenic, cadmium, and chromium (conservatively assumed to exist in the carcinogenic hexavalent form) ranges from $<1 \times 10^{-10}$ at the Boss, MO facility to $<9 \times 10^{-7}$ at the facility in Herculaneum, MO. The highest cancer risks were predicted at the Herculaneum facility because the maximum exposed individual at this site lives only 15 meters from the slag pile.

¹⁵ The approximate distance from the slag pile to the maximum exposed individual is 915 meters at the Boss facility, 15 meters at the Herculaneum facility, 180 meters at the East Helena facility, and 60 meters at the Glover facility.

- The predicted concentrations of selenium in the air were more than two orders of magnitude below the threshold concentration that is associated with dermatitis and gastrointestinal tract disturbances.
- The predicted concentrations of lead in the air were more than two orders of magnitude below the National Ambient Air Quality Standard.

EPA also estimated inhalation risks in the middle of population centers near the East Helena and Herculaneum facilities (the Glover and Boss facilities are located in sparsely populated areas with roughly 840 and 1,800 people currently living within 8 km (5 miles) of each of these plants, respectively). Approximately 7,700 people live between 1.6 km and 8 km to the west of the East Helena facility, and EPA's estimate of cancer risk caused by the inhalation of lead slag dust at the center of this population area is approximately 5×10^{-10} . Similarly, roughly 12,000 people live between 1.6 km and 8 km to the south and south-southwest of the Herculaneum facility; the inhalation of lead slag dust in the middle of this population center poses a cancer risk of less than 7×10^{-9} . The predicted concentrations of selenium and lead in the air at the population centers near both of these facilities were also well below the hazard criteria, as they were at the nearest residences.

10.3.2 Damage Cases

State and EPA regional files were reviewed in an effort to document the environmental performance of lead slag waste management practices at all four active lead smelters: ASARCO in East Helena, Montana; ASARCO in Glover, Missouri; Doe Run in Herculaneum, Missouri; and Doe Run's Buick smelter in Boss, Missouri. No documented environmental damages associated with the slag piles were identified for the Herculaneum facility, based on the limited monitoring data available for this site. The two ASARCO facilities and the Boss, Missouri facility were found to have documented exceedances of drinking water standards or water quality criteria in ground or surface waters that have been caused at least in part by the lead slag piles at the facilities. Two additional facilities, ASARCO in El Paso, Texas, and Midvale Slag in Midvale, Utah, have combined lead, copper, and zinc slags on site which have resulted in documented environmental damages. Each of the six sites identified with documented damages is discussed below.

ASARCO, East Helena, Montana

This facility, which started operation in 1888, is located immediately adjacent to the town of East Helena, five miles east of Helena, and covers approximately 32 hectares (80 acres). Numerous private wells surrounding this facility are used as sources of drinking water.¹⁶

The smelter currently produces lead bullion that is shipped to the ASARCO facility in Omaha, where it is further refined. An on-site zinc fuming operation further refined the lead slag from 1927 until 1982. Through this process, zinc was recovered by injecting air into the molten lead slag and recovering zinc oxide. ASARCO suspended operation of the zinc fuming department in 1982 because it was uneconomical. More than six million tons of fumed slag has been placed on 11 hectares (28 acres) along the northeastern boundary of the plant property. Beginning in 1982, ASARCO placed the unfumed slag in a segregated area adjacent to the fumed slag piles. The 300,000 tons of unfumed slag covers about 18,000 square meters (4.5 acres). Up until January 1989, the unfumed slag was poured in molten form on a slag pile adjacent to the plant. ASARCO currently air cools the slag in steel vessels before disposal.

Initial evidence of contamination originating from the slag piles was found in 1979, when a Montana Department of Health and Environmental Sciences (MDHES) inspector reported water seeps flowing from the slag piles into an adjacent creek. The inspector described the seeps as "a grayish steaming flow discharging to the creek at an estimated 2 cfs." The inspector also noted that the discharge "appeared to be flowing from under the slag piles at ASARCO." As shown in Exhibit 10-7, these seeps were found to contain elevated levels

¹⁶ ASARCO. 1986. Draft Report on Water Resources Monitoring - Asarco East Helena Plant.

Exhibit 10-7
Results of Surface Water Sampling and Analysis
ASARCO, East Helena, Montana

Sampling Date		Parameter (mg/L)					
		Pb	As	Cu	Zn	Cd	Mn
ABOVE SLAG PILE							
10/24/80	Prickley Pear Creek Above ASARCO Dam	<0.03	<u>0.20</u> ^(a)	0.01	0.29	<.005	0.34
10/23/80	Prickley Pear Creek Above Green Discharge	<0.05	<u>0.20</u>	0.01	0.34	0.01	0.25
10/23/80	Prickley Pear Creek Below Green Discharge	0.05	<u>2.02</u>	0.01	0.37	<u>0.04</u>	0.27
10/24/80	Prickley Pear Creek Below Green Discharge	<0.05	<u>0.075</u>	0.01	0.34	<0.005	0.29
DISCHARGE FROM SLAG PILE							
02/19/80	Seep from Slag Pile	<u>0.07</u>	<u>80</u>	0.04	0.06	--	0.26
03/05/80	Seep from Slag Pile	<0.05	<u>70</u>	0.01	0.04	--	0.18
03/11/80	Seep from Slag Pile	0.05	<u>75</u>	0.11	0.08	<0.005	0.24
BELOW SLAG PILE SEEPS							
10/15/79	Prickley Pear Creek Above Main Discharge	<0.05	0.04	0.02	0.15	0.004	--
10/31/79	Prickley Pear Creek Above Main Discharge	<0.05	<u>0.08</u>	0.01	0.11	<0.005	--
BELOW SLAG PILE AND MAIN FACILITY DISCHARGE							
11/01/79	Prickley Pear Creek Below both Discharge Points	<u>0.12</u>	<u>3.65</u>	0.02	0.20	<u>0.03</u>	--
11/01/79	Prickley Pear Creek Below both Discharge Points	<u>0.12</u>	<u>3.65</u>	0.02	0.20	<u>0.03</u>	--
BELOW SLAG PILE AND BOTH FACILITY DISCHARGES							
10/15/79	Prickly Pear Creek Below Main Discharge	<0.05	0.04	0.01	0.16	0.004	--
10/31/79	Prickly Pear Creek Below Main Discharge	<0.05	<u>0.90</u>	0.01	0.14	0.01	--

(a) The concentrations which are underlined represent exceedances of the MCL, based on the National Primary Drinking Water Regulations.

of arsenic and lead. Samples of the seep water showed arsenic concentrations from 70 to 80 mg/L. The MDHES states that years of mining in the Prickley Creek headwaters has yielded arsenic levels above MCLs upstream from the plant site.¹⁷ Monitoring data from the creek did not show a definite increase in in-stream concentrations of arsenic. As reported by MDHES, the seeps were caused by ASARCO's practice of spraying the pile with contaminated wastewater

¹⁷ Montana Department of Health and Environmental Sciences, 1990. Letter from G. Mullen to K. McCarthy, ICF Incorporated, Re: Comments on E. Helena and Anaconda Facilities. May.

for the purpose of dust control. The discharge to the creek from the seeps was eliminated when ASARCO ceased sprinkling the slag with wastewater.¹⁸

This facility was listed on the Superfund National Priorities List (NPL) in 1983. Areas of the site identified as requiring study included process water ponds, slag piles, and areas with elevated levels of heavy metals in the soils. To facilitate these studies, the site was divided into five "operable units," one of which consists of the slag piles.¹⁹

Although a documented link has not been established, the slag piles have also been considered by ASARCO as potential sources of ground-water contamination. A ground-water monitoring investigation completed by ASARCO on February 7, 1986 indicated that concentrations of some heavy metals and arsenic in surface and ground-water exceeded drinking water standards. Specific data were not provided. All potential sources of contaminants were identified, and the list included the unfumed slag pile and the fumed slag pile.²⁰ Elevated levels of arsenic (up to 0.620 mg/L), zinc (up to 3.7 mg/L), and sulfates (up to 11,750 mg/L) were measured in 1987 by ASARCO in water from within the slag piles.²¹ Ground-water monitoring data from 1986 discussed in the 1987 Remedial Investigation for this site showed that monitoring wells downgradient of two process wastewater impoundments and the slag pile "have elevated concentrations of sulfate and arsenic."²² However, site maps showing the locations of the arsenic and sulfate plumes reveal that the contamination has been caused mainly by the wastewater impoundments, not the slag pile.

While two of the three wells downgradient of the slag pile showed elevated levels of arsenic, manganese and sulfate, the upgradient well also showed elevated levels of these contaminants. Exhibit 10-8 provides the results of these analyses. This upgradient well is located in the area influenced by seepage from the wastewater impoundments.

ASARCO, Glover, Missouri

ASARCO's Glover lead smelter is situated in a lead-rich region known as Missouri's "Old Lead Belt," within the Mark Twain National Forest in the Missouri Ozarks. ASARCO began operations at this facility in 1968. Slag generated by the smelter is stored in an on-site pile which is upslope and upgradient of the facility. Wastewater discharges (NPDES), surface run-off, and ground-water flow from the facility are all directed towards or into Big Creek. Although no documentation was found directly stating that the lead slag piles were the source of heavy metals releases to surface or ground waters, some of the data reviewed suggest that the lead slag is at least part of the source.

In May 1985, ASARCO conducted a hydrologic characterization of the Glover facility. Data from this study showed that, in contrast to background or upgradient samples, elevated cadmium, zinc, manganese, and possibly chromium concentrations were present in many surface and ground-water samples collected downgradient of the lead slag pile. (See Exhibit 10-9.) Cadmium concentrations exceeded the MCL by a significant amount in bedrock wells (0.027 - 0.053 mg/L) and shallow wells (0.52 - 2.3 mg/L), as well as surface waters (0.52 - 4.3 mg/L) downgradient of the slag.

Manganese and zinc were also present in the shallow wells and surface water downgradient from the slag pile.²³ Background values for the deep aquifer were not available.

¹⁸ Montana Department of Health and Environmental Sciences, 1980. Laboratory Analysis from Slag Pile, and Preliminary Investigation Notes for Slag Pile.

¹⁹ EPA Region VIII and Montana Department of Health and Environmental Sciences, 1989. Superfund Program Proposed Plan - East Helena Smelter Site.

²⁰ ASARCO, 1986. Draft Report on Water Resources Monitoring - Asarco East Helena Plant.

²¹ ASARCO, 1986. Test Hole Logs performed for Asarco by Hydrometrics and miscellaneous sample results from Asarco tests.

²² CH²M Hill, 1987. East Helena Smelter (Asarco) Site Profile.

²³ ASARCO, 1990. Letter from G.F. Lubbers, ASARCO Glover, to D. Bussard, EPA Headquarters, Waste Management Division, Re: (None) Response to data request.

Exhibit 10-8
Results from Groundwater Quality Analysis
ASARCO, East Helena, Montana

Sampling Date	Well Name ^(a)	Parameter (mg/L)					
		Pb	As	Cu	SO ₄	Cd	Mn
01/06/85	DH-6 ^(b)	<0.005	<u>8.4</u> ^(d)	0.013	545 ^(e)	<0.001	0.054
01/18/85	DH-7 ^(b)	<0.005	0.005	<0.008	74.7	<0.001	0.041
01/18/85	DH-10 ^(b)	<0.005	<u>5.10</u>	0.009	352	0.003	4.80
06/11/85	Dh-9 ^(c)	0.007	10.4	0.010	415	0.006	0.463

- (a) It appears that most of the private wells in East Helena are drilled at depths ranging from 10 to 49 meters. Thus, it can reasonably be expected that the depth to groundwater for the above wells is similar.
- (b) Based on potentiometric surface maps of the site, these sampling points appear to be downgradient of the slag pile.
- (c) Based on the same maps mentioned above, it appears that this sampling point is upgradient of the slag pile.
- (d) The concentrations which are underlined represent exceedances of the National Primary Drinking Water Regulations.
- (e) The concentrations in bold (not underlined) represent exceedances of the National Secondary Drinking Water Regulations.

Exhibit 10-9
Summary of Exceedances from Well and Surface Water Analyses
ASARCO, Glover, Missouri

Station ^(a)	Total No. Samples ^(b)	No. Samples Exceeding MCL/Maximum Exceedance Factor ^(c)						
		Cd	Fe	Mn	Pb	Zn	TDS	SO ₄
Deep Aquifer Downgradient 103D	3	2/5.3	0	0	2/1.4	0	3/4.04	3/4.52
Shallow Aquifer Upgradient 101	6	0	0	0	1/1.4	0	0	0
102	6	0	0	0	0	0	0	0
Downgradient MW-4	6	6/230	1/2.1	5/2.4	3/2.4	2/1.86	6/4.01	6/4.76
103	3	3/4.5	0	0	0	0	3/1.88	3/1.82
104	6	6/57	6/6.8	6/9.9	1/1.6	0	5/2.29	3/2.41
105	6	0	0	4/2.3	1/1.6	0	0	0
MW-3	6	3/1.7	0	0	3/1.6	0	0	0
Surface Water Scroggins Branch 300	5	0	0	0	0	0	0	0
301	6	1/1.2	0	0	1/1.6	0	0	0
Slag Seep 303	6	6/430	0	1/1.26	6/5.6	5/7.14	6/2.65	6/3.28

- (a) ♦Bedrock Well = 103D (Depth to gw=12.3m; distance from slag pile<50m).
 ♦Shallow Wells=MW-4 (depth<2m; distance=100m); MW-3 (depth<3m; distance=100m); 104 (depth=1m; distance=100m); and 105 (depth=1.7m; distance<200m); Background (referenced by ASARCO) = 101 (depth=0.76m; distance=244m); and 102 (depth=1.2m; distance=732m).
 ♦Surface Water Station=303 (Slag Pile Seep); Background - Scroggins Branch (referenced by ASARCO)=300 (distance from slag pile=244m) and 301 (distance=152m).
- (b) ♦Samples collected between 8/84 and 3/86.

- (c) First value is number of samples exceeding MCL. Second value is Maximum Exceedance Factor, derived by dividing highest concentration detected by the MCL (e.g., a concentration of 0.12 mg/L lead exceeds the MCL of 0.05 mg/L by a factor of 2.4).

In October 1985, the Missouri Department of Natural Resources (MODNR) stated, based on the data reviewed up to that time, that "[e]ither there is a very significant nonpoint source of cadmium or there are significant unreported discharges from ASARCO or there are both."²⁴

In May 1987, EPA conducted a Potential Hazardous Waste Site investigation, and expressed concern that "surface water run-off from slag piles could be contaminating the streams surrounding the lead smelter with heavy metals."²⁵ In 1988, under a Settlement Agreement with the MODNR, ASARCO constructed a collection and treatment system for stormwater run-off from the facility, including the slag area.

Doe Run, Boss, Missouri

Doe Run's Buick primary smelter facility, like ASARCO's Glover facility, is situated within Missouri's "Old Lead Belt." The facility, which began operating in 1968, was originally owned by the Amax Lead Company and is also known as the AMAX Homestake Smelter. The 101 hectare (250-acre) plant is located near the towns of Boss and Bixby, Missouri, in Iron County.

The site is located on a ridge separating the watersheds of the Left Fork of Neals Creek (to the south) from that of Crooked Creek (to the north.) This area has been identified as a recharge area for the underlying aquifer. There are private drinking water wells within a 1.6 km radius of the facility. The water table occurs at 44.2 m (145 feet) below the land surface in both the wet and dry seasons. A perched water table also exists at five feet below the land surface. Crooked Creek receives wastewater discharges from smelting operations, while Strother Creek receives discharges from the mine and mill. The mean annual precipitation is about 1.2 meters (46 inches).²⁶

The slag disposal area consists of a flat-topped "bench" along the eastern side of the head of a small valley that is underlain by clay-based residuum. The slag is piped as a slurry to the slag disposal area where it is dewatered, then trucked to the on-site sinter plant for reuse as sinter, or disposed in the slag disposal area.²⁷ A total of about 480,000 tons of slag have been placed in the slag disposal area over nearly 20 years of primary smelter operation. The piled slag covers about 20,000 square meters (5 acres) at its base with a thickness of 6.1 to 16.8 meters (20 to 55 feet).²⁸ The slag pile is generally unvegetated.

In 1984 EPA Region VII performed a Potential Hazardous Waste Site Preliminary Assessment. The inspector found that "surface impoundments and slag piles containing heavy metals could possibly contaminate ground and surface water." The inspector also listed blowing dust from the slag pile under "Hazardous Conditions and Incidents."²⁹

Doe Run began a comprehensive investigation of the primary smelter slag disposal area in 1984. Soil boring analyses revealed that some residuum samples from beneath the slag contained elevated concentrations of lead, zinc, and cadmium. Exhibit 10-10 shows analyses of boring samples typical for uncontaminated residuum, contaminated residuum, and the slag itself. These data show that uncontaminated residuum might contain up to 10 mg/kg lead. The slag itself may contain 3,800 mg/kg, while the residuum contaminated from slag leachate may contain 2,400 mg/kg lead. Similar comparisons can be made for zinc and cadmium, and possibly copper.³⁰

²⁴ Missouri Department of Natural Resources, 1985. Memo from J. Ford to R. Hentges, Re: Discharges from the ASARCO smelter at Glover.

²⁵ U.S. EPA Region VII, 1987. Potential Hazardous Waste Site, Site Identification, for ASARCO lead smelter in Glover, Missouri.

²⁶ Doe Run Company, 1989. Buick Resource Recovery Facility RCRA Part B Permit Application.

²⁷ *Ibid.*

²⁸ Barr Engineering, 1989. Letter from D. Connell to D. Kennedy, Region VII, Re: Revised RCRA Facility Assessment Report (Copy of Report Attached).

²⁹ U.S. EPA Region VII, 1984. Potential Hazardous Waste Site, Preliminary Assessment, for Amax Lead Co. smelter in Boss, Missouri.

³⁰ Doe Run Company, 1989. Buick Resource Recovery Facility RCRA Part B Permit Application.

Exhibit 10-10
Metals Content of Slag and Residuum
Doe Run, Boss, Missouri

Sample	Description	Depth (ft)	Concentration (mg/kg)			
			Pb	Zn	Cd	Cu
K1	Residuum	16 - 16.5	5.4	16	0.11	37
K2	Residuum	54 - 54.5	10	27	0.13	41
K9	Residuum	43.5 - 44	2,400	390	7.3	160
K10	Residuum	21 - 22	990	230	2.8	28
K9	Slag Pile	24 - 24.5	3,800	6,800	14	250

Monitoring well data from 1988 show that cadmium, lead, and zinc concentrations in the ground water below the slag disposal area exceed drinking water standards. These data, summarized in Exhibit 10-11, show that contamination of the ground water below the slag disposal area has occurred, though it is unclear if this contamination can be attributed to the slag pile directly or to two adjacent impoundments that contain water from the slag storage area. Several independent laboratories analyzed subsamples of each sample to derive a mean value. Mean cadmium levels ranged up to 0.67 mg/L (67 times the MCL); lead ranged up to 0.6 mg/L (12 times the MCL); and one mean value for zinc contained 7.4 mg/L (1.5 times the MCL). Three wells had consistently elevated cadmium levels: the 11 samples from well K2 averaged 0.087 mg/L; the six samples from well K5A averaged 0.431 mg/L; and the six samples from well K8 averaged 0.021 mg/L. These wells were all located within 125m of the slag disposal area, and all appeared to be downgradient.³¹ Background monitoring well data were not located in the available documentation.

Midvale Slag, Midvale, Utah

Slags from both primary copper and lead smelting operations have been co-disposed at this facility. Heavy-metal contamination of ground-water has been linked to these slag deposits. This situation is more fully described under Damage Case Study Findings for the copper sector (Section 6.3.2).

ASARCO, El Paso, Texas

This facility contains combined deposits of lead, copper, and zinc slag. Heavy metal contamination of water and sediments in the Rio Grande River have been linked to these slag deposits. This situation is more fully described under Damage Case Study Findings for the copper sector (Section 6.3.2).

10.3.3 Findings Concerning the Hazards of Lead Slag

Review of available data on the slag and slag leachate constituent concentrations indicates that 12 constituents are present in concentrations that exceed the risk screening criteria used in this analysis by more than a factor of 10: arsenic, cadmium, chromium, lead, selenium, antimony, silver, zinc, iron, cobalt, manganese, and mercury. Of these constituents, arsenic, cadmium, lead, mercury, and selenium in lead slag leachate were also measured using the EP leach

³¹ *Ibid.*

test in concentrations that exceed EP regulatory levels. Concentrations measured using the SPLP leachate test, however, never exceeded the EP regulatory level.

Exhibit 10-11
Summary Monitoring Well Data for the Slag Disposal Area^(a)
Doe Run, Boss, Missouri

Well No.	Depth to g.w. (ft)	Date	Averaged Results from 3 to 4 Labs (mg/L)			
			Cd (0.01) ^(b)	Pb (0.05) ^(b)	Zn (5.00) ^(c)	Mn (0.5) ^(c)
K2	42.4	06/09/88	0.08			2.0
K2	42.4	07/07/88	0.07	0.09	--	2.5
K2	42.4	08/10/88	0.09	0.60		2.7
K2	42.4	09/15/88	0.12	--	--	4.1
K2	42.4	10/13/88	0.082			3.0
K5a	24.0	06/09/88	0.48	--	--	0.84
K5a	24.0	09/15/88	0.67		7.4	1.7
K6	10.9	08/10/88	--	0.08	--	--
K8	81.0	06/09/88	0.21	0.08		1.8
K8	81.0	09/15/88	0.022	--	--	2.9
K10	138.1	07/07/88				2.3
K10	138.1	08/10/88	--	0.08	--	0.66
K12	95.1	08/10/88		0.06		
K13	136.3	06/09/88	--	0.118	--	1.2
K13	136.3	07/07/88		0.077		1.7
K13	136.3	08/10/88	--	0.08	--	1.6
K13	136.3	09/15/88				1.9

- (a) By noting positions on potentiometric map, wells were all downgradient, and within 125m of slag disposal area.
(b) Primary MCL (mg/L)
(c) Secondary MCL (mg/L)

Based on an examination of the characteristics of each site and predictive modeling, the most likely pathway for contaminants to be released into the environment is through erosion to surface water. At the Glover, East Helena, and Boss facilities, the Agency estimated that, without any run-off controls, erosion from lead slag piles may result in annual average concentrations of arsenic, lead, iron, manganese, and/or zinc in nearby creeks that exceed human health and ecological protection criteria, by as much as a factor of 19. However, run-off from the slag piles at the Glover and Boss facilities is presently collected and treated prior to discharge. Depending on the efficiency of these control systems, surface water contamination caused by slag pile run-off at Glover and Boss is likely to be significantly lower than predicted.

Significant releases to ground water appear less likely considering the generally low net recharge, low permeability of the earth materials underlying the slag piles, and large depths to useable ground water at each facility, as well as the tendency of most of the metals in lead slag to bind to soil. At three facilities, the Agency predicts that the metals from lead slag piles would be largely bound to subsurface soil and would not reach ground water within 200 years. However, the Agency's modeling indicates that, under natural recharge conditions, ground water within the facility

boundary at Glover and East Helena could be contaminated with cobalt in excess of irrigation guidelines. Also at Glover, the Agency predicts that arsenic concentrations in ground water could cause a cancer risk of 4×10^{-7} , but this contamination is expected to be confined to the facility property and is well below the MCL.

Air pathway modeling indicates that it is very unlikely for slag piles to cause harmful concentrations of contaminants in the air at the nearest residences.

Monitoring data collected during the Agency's efforts to identify documented cases of damage confirm the existence of high contaminant concentrations in leachate seeps and/or run-off from lead slag piles. In particular, monitoring data show that "surface water seeps" from slag piles at the Glover and East Helena facilities contain arsenic, lead, and/or cadmium in concentrations that exceed the primary drinking water standards. These seeps appear to represent largely undiluted leachate and run-off, rather than ambient surface water concentrations after contaminants have been fully mixed in the flow of nearby creeks, as analyzed by the modeling. However, the documented presence of the seeps and their high contaminant concentrations generally support the modeling conclusion that run-off, if not controlled, could be an important contributor to surface water contamination. As noted above, the Glover facility now collects and treats fluids coming from the pile prior to discharge. In addition, the East Helena facility has discontinued the practice of sprinkling the pile with wastewater to control dust, which was believed to be the primary source of the slag pile seepage.

Information collected during the damage case research also suggests that the slag pile at the Boss facility may be a source of surface water contamination. Site-specific modeling at this facility predicts that run-off from the slag pile, if not controlled, could result in iron and manganese concentrations in Crooked Creek that exceed the MCLs by a factor of 2, and lead concentrations that exceed the proposed revised MCL for lead by a factor of 12. This creek, however, is not currently used as a source of drinking water within 24 km of the facility, and given its low flow (16 mgd), it is uncertain if it could provide a drinking water supply in the future. Furthermore, the slag pile is equipped with stormwater run-off controls, and the actual contaminant concentrations in Crooked Creek are likely to be lower than predicted.

Monitoring data collected for the damage cases suggest more ground-water contamination than is predicted by the modeling. Monitoring data for the Glover, East Helena, and Boss facilities indicate that primary drinking water standards for lead, cadmium, and arsenic have been exceeded in ground water on the plant property. At all three sites, lead slag is only one of several possible sources of the observed contamination, though the slag pile appears to be the primary source of contamination of some of the wells at the Glover facility. The Agency's modeling predicts that the slag piles at Glover and East Helena may cause ground water contamination, but not at the levels and downgradient distances that were observed. Similarly, the Agency predicted essentially no ground-water contamination at Boss. These differences appear to be caused by the following factors:

- It appears likely that the contamination observed in a well approximately 100 meters downgradient from the slag pile at Glover was caused, in part, by overland migration of fluids from the pile. As described previously, highly concentrated "surface seeps" near the base of the pile have been observed at this site. Prior to the installation of run-off controls in 1988, it may have been possible for this seepage to migrate over the land or through drainage ditches and then percolate into this shallow well (which is screened at a depth of only 2 meters).
- The slag pile at the East Helena facility is downgradient from two process wastewater ponds that appear to be the principal contributors to ground-water contamination. The documented presence of contamination upgradient of the slag pile substantiates that other release sources are likely to exist. Furthermore, it is possible that some, if not most, of the ground-water contamination potentially attributable to the slag pile was caused by the former practice of sprinkling contaminated wastewater on the pile for the purpose of dust control. This water added to the pile provided a much larger contaminant load and created a much greater potential for leaching than the naturally low precipitation and recharge considered in the modeling.
- The slag pile at the Boss facility is adjacent to two unlined impoundments that may be contributing to the observed contamination. In addition, the facility is underlain by dolomite, which is prone to form solution cavities that can allow contaminants to migrate readily in ground

water. It is possible that some of the observed ground-water contamination at this site migrated through such cavities, which were not considered in the modeling.

10.4 Existing Federal and State Waste Management Controls

10.4.1 Federal Regulations

Under the Clean Water Act, EPA has the responsibility for setting "effluent limitations," based on the performance capability of treatment technologies. These "technology based limitations" which provide the basis for the minimum requirements of NPDES permits, must be established for various classes of industrial discharges, including a number of ore processing categories.

Permits for mineral processing facilities may require compliance with effluent guidelines based on best practicable control technology currently available (BPT) or best available technology economically achievable (BAT). BPT effluent limitations allow no discharge from hard-lead refining slag granulation. These limitations do not apply to stormwater point sources, such as run-off from a slag pile, or to mining and beneficiation operations. Other processes related to slag management for which discharges are allowed include:

Dross reverberatory slag granulation (40 CFR 421.72(d)):

Pollutant	Daily Maximum	Average Maximum Monthly
Total Suspended Solids	236,000 mg/kg	112,300 mg/kg
Lead	9,499 mg/kg	4,318 mg/kg
Zinc	8,405 mg/kg	3,512 mg/kg
pH	7.5 - 10	

Blast furnace slag granulation (40 CFR 421.72(c)):

Pollutant	Daily Maximum	Average Maximum Monthly
Total Suspended Solids	153,000 mg/kg	72,400 mg/kg
Lead	6,155 mg/kg	2,798 mg/kg
Zinc	5,446 mg/kg	2,276 mg/kg
pH	7.5 - 10	

BAT limits for existing sources for processes related to slag management include:

Dross reverberatory slag granulation (40 CFR 421.73(d)):

Pollutant	Daily Maximum	Average Maximum Monthly
Lead	1,612 mg/kg	784.4 mg/kg
Zinc	5,872 mg/kg	2,418 mg/kg

No discharges are allowed under BAT from blast furnace slag granulation or hard lead refining slag granulation. No discharges of slag waters are allowed from new sources (40 CFR 421.73(c), 421.74(c) and (d)).

EPA has, under the Clean Air Act (40 CFR 60.180), established the national primary and secondary ambient air quality standards (NESHAP) for lead at 1.5 $\mu\text{g}/\text{m}^3$.

10.4.2 State Regulation

The five primary lead processing facilities that generate lead slag are located in Missouri (three facilities), Montana (one facility), and Nebraska (one facility). Only Missouri and Montana were selected for detailed regulatory review for the purposes of this report (see Chapter 2 for a discussion of the methodology used to select states for detailed regulatory study).

All three states with facilities generating lead slag exclude mineral processing wastes from their hazardous waste regulations. Historically, Missouri also has not addressed lead slag under its solid waste regulations. Montana classifies lead slag as solid waste, but exempts solid wastes managed on-site, such as the slag generated at the East Helena facility, from regulatory requirements. Although not studied in detail, a brief review of Nebraska's regulations suggests that this state does not address lead slag as a solid waste. Missouri does currently require owners/operators of lead facilities to obtain NPDES permits for storm water discharges, and thus establish run-on/run-off controls. According to state officials in Montana, run-off from lead slag piles does not require a NPDES permit and is not addressed otherwise. Finally, although mineral processing facilities in both states must obtain air permits in order to operate, there are no specific regulations addressing fugitive dust suppression for lead slag in either state.

In contrast to this current lack of formal control, Missouri recently passed a Metallic Minerals Waste Management Act, which will apply to generators of lead slag. This act requires that facility owners/operators submit permit applications for active existing and new operations. Each permit application must include operating information, a detailed closure plan, an inspection and maintenance plan, and provisions for financial assurance. Nonetheless, because the state has not yet promulgated regulations to implement the Act, and the first permitting cycle has not yet been completed, the extent and nature of environmental controls that will ultimately be imposed on the slag management activities of the state's three facilities cannot be predicted.

In summary, neither of the two study states with primary lead processing facilities have imposed environmental controls, under either hazardous or solid waste regulatory authorities, on the lead slag management activities conducted at those facilities in the past. Moreover, although Missouri recently enacted new minerals waste legislation and appears to be preparing to actively address lead slag, the state has not yet promulgated regulations to implement that legislation. The nature and extent of environmental control requirements ultimately placed on lead slag wastes, therefore, cannot be predicted with confidence at this time.

10.5 Waste Management Alternatives and Potential Utilization

10.5.1 Waste Management Alternatives

Waste management alternatives, as discussed here, include both waste disposal (e.g., in landfills and waste piles) alternatives and methods of minimizing the amount of waste generated. Waste minimization alternatives include any source reduction or recycling that results in either the reduction of total volume or toxicity of the waste. Source reduction is a reduction of waste generation at the source, usually within a process. Source reduction can include: process modifications, feedstock (raw material) substitution, housekeeping and management practices, and increases in efficiency of machinery and equipment. Source reduction includes any activity that reduces the amount of waste that exits a process. Recycling refers to the use or reuse of a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in an industrial process.

Opportunities for waste minimization through raw materials substitutions are limited in general by the characteristics of the ores that are processed. Selection of source ores and improved beneficiation techniques, however, may lead to reduced slag volumes in some cases. Other source reduction opportunities may involve process modifications that increase the efficiency of metal recovery during the smelting operation.

Recycling blast furnace slag to the sinter plant, and recovering lead and zinc from the slag by slag fuming, are the primary waste minimization practices currently employed in the primary lead processing sector.

Recycling Lead Slag

Description

The purpose of recycling blast furnace slag to the sinter plant is to recover metals that would otherwise remain in the slag, and to control the concentration of lead in the materials being fed to the sinter plant. When recycled, the slag is blended with the other sinter plant input materials (e.g., ore concentrates, flue dust, and fluxes). The resulting mixture is pelletized and roasted in the sinter plant. At facilities which practice slag recycling, approximately 36 percent of the sinter plant's feed is made up of slag.³²

Current and Potential Use

Of the five primary lead processing facilities in the U.S., the three facilities in Missouri recycle as much as 73 percent of their slag to the sinter plant.³³ The galena ore in Missouri is rich in lead content, so that the facilities there may need to recycle their slag to the sinter plant, even if it means retrieving slag from the waste pile.³⁴

The ASARCO facilities in East Helena, Montana and Omaha, Nebraska do not recycle their lead slag.³⁵ Presumably the East Helena facility does not recycle its slag because the lead concentrations of the ore concentrate they process are lower than in the Missouri ore concentrate (74-76 weight percent).³⁶ ASARCO's facility in Omaha, Nebraska

³² PEDCo Environmental, Inc., 1980. Industrial Process Profiles for Environmental Use. Chapter 27: Primary Lead Industry, EPA-600/2-80-168, Environmental Protection Technology Series, Industrial Environmental Research Laboratory, ORD, U.S. Environmental Protection Agency, July, p. 25.

³³ Doe Run, 1989. Company Response to the "National Survey of Solid Wastes from Mineral Processing Facilities," U.S. EPA, 1989.

³⁴ Ibid.

³⁵ EPA in house information, July 1987.

³⁶ PEDCo Environmental, Inc., op. cit. pp. 17-18.

does not have the option of recycling its slag on-site since it only refines lead bullion and does not have a sinter plant or blast furnace. Apparently it is not economically feasible to transport the slag to another facility for recycling.

Therefore, of the two facilities that do not recycle their slag, only East Helena has the alternative available, and it is uncertain what impact recycling would have on the volume or composition of slag being generated. The amount of slag being recycled at the three Missouri facilities could perhaps be increased by implementing process modifications, but it is uncertain whether this would significantly reduce the quantity of slag ultimately disposed.

Factors Relevant to Regulatory Status

While the specific effects of slag recycling on slag volume and composition are uncertain, data on the composition of slag from different ores and refining processes^{37,38,39} suggest that recycling will not reduce waste volume or lead content by more than a few percent. Therefore, the use of recycling is unlikely to change the way in which lead slag should be regulated.

Feasibility

The recycling of slag at ASARCO's East Helena facility is almost certainly technically feasible, as is the possibility of increasing the amount of slag being recycled at the three Missouri facilities, but it is not certain that more recycling would be profitable. The primary factor influencing a facility's decision to recycle smelter slag is the concentration of metal in the slag. Slags with low lead content are likely to be disposed of instead of recycled due to the increased costs associated with recycling and the minimal benefits (e.g., small quantities of lead recovered).

Slag Fuming

Description

The primary purpose of slag fuming is to recover zinc oxides, created through reoxidation of the metals in the bottom portion of the blast furnace, which would otherwise remain in the slag. Lead recovery by slag fuming is also possible to some extent. Slag fuming is done by charging the molten lead slag to a fume furnace and injecting a stream of air and pulverized coal to maintain the necessary temperature and a reducing environment. The zinc and lead are then reoxidized by a stream of secondary air above the surface of the slag, and collected as particulate matter from the furnace gases.⁴⁰

The waste streams from slag fuming consist of the exhaust gas, which contains the zinc and lead being recovered and the volatile components of the blast furnace slag,⁴¹ the remaining slag, and water used to quench and granulate the slag. The exhaust gas is controlled/treated by first cooling it and then sending it to baghouses where the particles are removed and the volatile components are condensed. The remaining slag is believed to be physically and chemically similar to unfumed slag, being made up of compounds of aluminum, calcium, iron, magnesium, silicon, and other elements.⁴² (The main difference between fumed and unfumed slag is the reduced concentrations of lead, zinc, and volatile components in the fumed slag.) The fumed slag is disposed of by cooling it with either air or water (which

³⁷ *Ibid.*, p. 37.

³⁸ Higgins, Leo M. III, William H. Bauer, and Dodd S. Carr, 1980. "Utilization of Lead and Zinc Slags in Ceramic Construction Products," *Conservation & Recycling*, Vol. 3, p. 376.

³⁹ Collins, R.J. and R.H. Miller, 1976. *Availability of Mining Wastes and Their Potential for Use as Highway Material - Volume I: Classification and Technical and Environmental Analysis*, FHWA-RD-76-106, prepared for Federal Highway Administration, May, p. 119.

⁴⁰ PEDCo Environmental, Inc., *op. cit.* p. 42.

⁴¹ *Ibid.*

⁴² *Ibid.*

granulates it), and sending the cooled slag to a waste pile or tailings pond. When water is used to quench the fumed slag, the concentrations of sulfate have been observed to increase by 70 ppm, lead by 0.18 ppm, and zinc by 0.38 ppm,⁴³ which are comparable to the changes seen in unfumed slag quench water. Water used to quench and granulate the slag may undergo some form of treatment before being reused or discharged, but the portion used to slurry the granulated slag is often disposed with the slag.

Current and Potential Use

Of the four active U.S. facilities with smelting operations, none are currently using slag fuming to recover zinc oxide or lead from their blast furnace slag. At present, only the ASARCO facility in East Helena, Montana is believed to have slag fuming equipment installed, but it has not fumed slag since the early 1980's. The three facilities in Missouri also used to run slag fuming operations but no longer do so, and have removed their fuming ovens. EPA believes that the reason these facilities no longer have active fuming operations is that electric arc furnace dust from steel production and zinc slab are sources of purer, less expensive zinc oxide. If the price of zinc oxide were to rise, it is possible that ASARCO's East Helena facility would resume slag fuming. The lead facilities in Missouri might also resume slag fuming, but they would require more incentive than the East Helena facility, because they would have to install fuming equipment.

Factors Relevant to Regulatory Status

Lead and zinc concentrations in lead slag can range from 0.1 to 3.5 and from 2.0 to 17.5 percent by weight, respectively.^{44,45} Therefore, even with complete lead and zinc recovery, slag fuming could reduce the amount of slag generated by a maximum of 21 percent by weight, and perhaps by as little as 2.1 percent by weight. Assuming an annual slag production of 540,000 metric tons,^{46,47} that all of the slag is fumed, and that all of the lead and zinc are recovered from the slag, the amount of slag would be reduced by 11,340-113,400 metric tons per year.

EPA does not believe that the use of slag fuming is likely to result in the need for regulations more stringent than would be applied to unfumed slag. In fact, fumed slag could potentially be of less concern than unfumed slag due to the lower toxic metal content.

Feasibility

While slag fuming may not be technically feasible at the ASARCO facility in Omaha, Nebraska, slag fuming has seen extensive use in the past at the facilities in Montana and Missouri. Therefore, its technical feasibility has been demonstrated. Economic feasibility hinges on the price of the zinc oxide produced and/or the benefits that might be derived from lowering the slag's lead and zinc concentrations.

Disposal Alternatives

Of the five lead processors, only the facility in Omaha, Nebraska sends its slag off-site for disposal. While it is conceivable that some, or even all, of the other lead processors could do so, the cost of transporting large volumes of lead slag, and the rising cost of commercial landfill capacity make it unlikely that lead processors will utilize off-site disposal capacity if on-site capacity is available and the regulations do not change.

⁴³ *Ibid.*, p. 43.

⁴⁴ *Ibid.*, p. 37.

⁴⁵ Collins, R.J. and R.H. Miller, *op. cit.* p. 119.

⁴⁶ This figure is based on the four smelting facilities operating at their maximum capacity and generating one ton of slag for every ton of lead.

⁴⁷ PEDCo Environmental, Inc., 1980, *op. cit.* p. 6.

10.5.2 Utilization

Utilization as a Construction Aggregate in Asphalt

Description

Lead slag has been used as an aggregate in asphalt used to surface roads. If the slag is water cooled (i.e., granulated) it may be usable with little or no crushing and screening. If, however, the slag is air-cooled, it will almost certainly require processing to produce the desired particle sizes. Once the slag has been sized it can then be mixed with the asphalt mixture.

Current and Potential Use

Lead slag was field tested as an aggregate in asphalt paving during the mid 1970s.⁴⁸ Lead slag has been shown to have desirable anti-skid and wear resistant properties,⁴⁹ and was used as an asphalt aggregate in eastern Missouri for a number of years in the 1970s. The Missouri State Highway Commission also made limited use of lead slag in asphalt mixtures used to patch and seal roads in the winter. In Idaho, the asphalt used to pave Interstate Route 90 utilized granulated lead slag as an aggregate.⁵⁰ EPA, however, has found no information indicating that lead slag is currently being used as an aggregate in asphalt road paving.

The potential of lead slag as a construction aggregate depends at least partly on its ability to compete successfully in the market place with the other sources of aggregates. Two of these factors are discussed below, and a third (competitive pricing) is discussed in the section on Feasibility.

Access to Markets

It is important that the waste be located as close as possible to its market in order to keep transportation costs low. Waste located within 80 and 160 km (50 to 100) miles of major metropolitan areas or aggregate shortage areas are considered as being near potential markets.⁵¹ The three facilities in Missouri are all located within 160 km (100 miles) of both St. Louis and Springfield. The facility in East Helena, Montana is located within 160 km (100 miles) of Butte and Helena, and within 320 km (200 miles) of an area in central Montana with an aggregate shortage. The ASARCO plant in Omaha, Nebraska is located within the metropolitan area of Omaha, and is within 160 km (100 miles) of southwestern Iowa, which has a shortage of aggregate. Therefore, all of the facilities have potential markets for use of their slag as an aggregate material.

Factors Relevant to Regulatory Status

The use of lead slag in asphalt is unlikely to alter the chemical composition of the slag. EPA believes that the physical entrainment of the slag in the asphalt will reduce the leaching of hazardous constituents from the slag as compared to disposal in an uncovered waste pile. However, to the extent that hazardous constituents do leach from slag used as aggregate in asphalt, the releases would be less controllable than those from a more localized source such as a waste pile.

⁴⁸ Collins, R.J. and R.H. Miller, op. cit. pp. 200 and 210.

⁴⁹ Ibid., p. 167.

⁵⁰ Ibid., p. 166.

⁵¹ Collins, R.J. and R.H. Miller, op. cit. p. 239.

Any slag particles that are too small to be used as an aggregate will still have to be disposed, unless they can be utilized in some other way (e.g., as a substitute for portland cement, as is discussed later). If disposed, there will be a greater potential for leaching or transport as dust due to the relatively small particle size.

Feasibility

The perception that lead slag might be harmful has entirely stopped its utilization as a component of asphalt for road paving. The use of granulated lead slag as an aggregate in asphalt in eastern Missouri was discontinued in the mid-1970s because the Missouri Department of Natural Resources suspected that there were significant amounts of lead in the slag, and that lead might escape into the environment through leaching. The Missouri lead producers, in order to avoid negative publicity, withdrew their slag from the market and chose instead to dispose of it as they had in the past.⁵²

In the event that the relevant agencies of State government were to reverse their position on this issue, the economic viability of lead slag as an aggregate would depend on the selling price of the slag, the cost of retrieving the slag from the disposal area, the amount of crushing and screening needed to size the slag, and the distance the slag would have to be transported prior to use.

10.5.3 Miscellaneous Utilization

There are a number of ways to utilize lead slag which are mentioned in the literature, but for which there is little information beyond the fact that a particular practice may have occurred. Below, EPA discusses and comments on each potential means of waste utilization to the extent permitted by the information available.

Substitute for Portland Cement in Construction Blocks

It has been shown that finely ground lead slag can be used to replace up to 25 percent of the portland cement in steam cured blocks without a significant loss in block strength.⁵³ The blocks are manufactured from a mixture of sand, portland cement, ground slag, and water, which is pressed into shape and then steam cured for 10 hours at 90 degrees centigrade. Whether the slag in such blocks would pose any risk to human health or the environment is not known; moreover, it is unclear whether the economics of utilization would be favorable, since the slag would require extensive grinding before use.

Frost Barrier and Buried Pipeline Bedding Material

In Idaho, granulated slag from the Bunker Hill Company smelter in Kellogg, Idaho (now closed), was used as a frost barrier under slabs of concrete and asphalt, as well as a bedding material for buried pipelines.⁵⁴ The literature does not report how much lead slag has been used for these purposes, or how it performed.

Using lead slag as a pipeline bedding or frost barrier material will not change the chemical or physical characteristics of the slag, although it may have some effect on the ability of the slag's hazardous constituents (e.g., lead and cadmium) to leach and contaminate ground and/or surface waters. For instance, when the slag is used as a frost barrier under cement or asphalt slabs, the amount and rate of leaching should be reduced significantly with respect to current slag waste management practices that allow water to run over the slag. When slag is used as bedding material for pipelines, the rate of leaching will depend on environmental settings, and could vary considerably.

⁵² *Ibid.*, p. 167.

⁵³ Higgins, Leo M. III, William H. Bauer, and Dodd S. Carr, *op. cit.* pp. 375-382.

⁵⁴ Collins, R.J. and R.H. Miller, *op. cit.*, p. 166.

Air-Blasting Abrasive

Lead slag has been used as an air-blasting abrasive. Slag from a closed smelter site (currently owned by the Valley Materials Corporation) in Midvale, Utah is being processed and sold as air-blasting abrasive by Blackhawk Slag Products in Utah, Colorado, and Nevada. The slag is processed into four different size grades and sold for such uses as the removal of paint from concrete and steel structures, as well as the removal of road paint stripes.⁵⁵

It is not known how much lead slag is currently being sold as air-blasting abrasive, or the scope of the potential market for this product. No information has been found to indicate that lead slag at other sites in the United States could not be utilized as air-blasting grit.

Virtually all of the slag that is used as input in the production of the abrasive is incorporated in the product, so disposal of the residues poses no problem. The primary concerns with respect to human health and the environment arise from the potential for inhaling the grit when it is used, and the leaching of heavy metals from the grit after it has been used. Blackhawk does not believe that the potential dangers from inhalation of the grit pose a significant threat to human health if people without protective equipment are kept away when it is being used.⁵⁶ It is not known how much of the grit might be picked up by the wind and inhaled by people. With respect to leaching, results from EP toxicity test extract analyses of the air-blasting grit were all well below the regulatory standards.⁵⁷

Railroad Ballast

Valley Materials Corporation in Midvale, Utah also is processing (sizing) slag for use as a railroad ballast. It is not known how much lead slag is currently being sold for use as railroad ballast, or the scope of the potential market for this product. No information has been found to indicate that lead slag at other sites in the United States could not be utilized in this way.

The slag at the Midvale site has been tested for EP Toxicity and found to be well below the regulatory standards.⁵⁸

10.6 Cost and Economic Impacts

Section 8002(p) of RCRA directs EPA to examine the costs of alternative practices for the management of the special wastes considered in this report. EPA has responded to this requirement by evaluating the operational changes that would be implied by compliance with three different regulatory scenarios, as described in Chapter 2. In reviewing and evaluating the Agency's estimates of the cost and economic impacts associated with these changes, it is important to remember what the regulatory scenarios imply, and what assumptions have been made in conducting the analysis.

The focus of the Subtitle C compliance scenario is on the costs of constructing and operating hazardous waste land disposal units. Other important aspects of the Subtitle C system (e.g., corrective action, prospective land disposal restrictions) have not been explicitly factored into the cost analysis. Therefore, differences between the costs estimated for Subtitle C compliance and those under other scenarios (particularly Subtitle C-Minus) are less than they might be under an alternative set of conditions (e.g., if land disposal restriction had been promulgated for "newly identified" hazardous wastes). The Subtitle C-Minus scenario represents, as discussed above in Chapter 2, the minimum requirements that would apply to any of the special wastes that are ultimately regulated as hazardous wastes; this scenario does not reflect any actual determinations or preliminary judgments concerning the specific requirements that would apply to any such wastes. Further, the Subtitle D-Plus scenario represents one of many possible approaches to a Subtitle D-Plus program for special mineral processing wastes, and has been included in this report only for illustrative

⁵⁵ Earthfax Engineering, Inc., 1986. Leaching Potential of Slag and Slag-Based Air-Blasting Abrasives, June.

⁵⁶ Private communication with Mr. Bob Soehnen, Vice President, Blackhawk Slag Products, Midvale, Utah, April 18, 1990.

⁵⁷ Earthfax Engineering, Inc., op. cit.

⁵⁸ Ibid.

purposes. The cost estimates provided below for the three scenarios considered in this report must be interpreted accordingly.

In accordance with the spirit of RCRA §8002(p), EPA has focused its analysis on impacts on the firms and facilities generating the special wastes, rather than on net impacts to society in the aggregate. Therefore, the cost analysis has been conducted on an after-tax basis, using a discount rate based on a previously developed estimate of the weighted-average cost of capital to U.S. industrial firms (9.49 percent), as discussed in Chapter 2. Waste generation rate estimates (which are directly proportional to costs) for the period of analysis (the present through 1995) have been developed in consultation with the U.S. Bureau of Mines.

In this section, EPA first outlines the way in which it has identified and evaluated the waste management practices that would be employed by primary lead producers under different regulatory scenarios. Next, the Agency discussed the cost implications of requiring these changes to existing waste management practices. The last part of this section predicts and discusses the ultimate impacts of the increased waste management costs faced by the affected lead facilities.

10.6.1 Regulatory Scenarios and Required Management Practices

Based upon the information presented earlier in this chapter, EPA believes that lead slag poses a relatively high risk, and is likely to exhibit the hazardous waste characteristic of EP toxicity. Accordingly, the Agency has estimated the costs associated with regulating lead slag under RCRA Subtitle C, as well as with two somewhat less stringent regulatory scenarios, referred to here as "Subtitle C-Minus" and "Subtitle D-Plus," as previously introduced in Chapter 2, and as described in specific detail below.

In the absence of actual facility-specific sampling and analysis data demonstrating otherwise, EPA has adopted a conservative approach in conducting its cost analysis, and has assumed that lead slag would exhibit EP toxicity at all five lead producing facilities.

Subtitle C

Under Subtitle C standards, generators of hazardous waste that is managed on-site must meet the standards codified at 40 CFR Parts 264 and 265 for hazardous waste treatment, storage, and disposal facilities. Because lead slag is a solid, non-combustible material, and because under full Subtitle C regulation, hazardous wastes cannot be permanently disposed of in waste piles, EPA has assumed in this analysis that the ultimate disposition of lead slag would be in Subtitle C landfills. Because, however, current practice at all five primary lead facilities is storage and/or disposal of slag in waste piles, the Agency has assumed that the facilities would also construct a temporary storage waste pile (with capacity of one week's waste generation) that would enable the operators to send the lead slag to either on-site or off-site disposal efficiently. Given the relatively large quantities of material generated at four of the five plants (all smelters), EPA has assumed that each of these four plants would, as applicable, continue to recycle the same quantity of slag as it does currently, and would dispose of the remainder in a landfill. To accommodate the portion disposed, EPA believes that, because of cost considerations, each facility operator would construct one on-site landfill that meets the minimum technology standards specified at 40 CFR 264, rather than ship the material off-site to a commercial hazardous waste landfill or build multiple landfills. The fifth facility (ASARCO-Omaha) currently ships its slag off-site for disposal; EPA assumes that this plant has disposal capacity restraints and is, therefore, likely to continue this practice. The facility would, however, have to send the slag to a commercial Subtitle C hazardous waste landfill rather than a commercial or municipal solid waste landfill (at a significant increase in waste management complexity and cost) under this scenario.

Subtitle C-Minus

A primary difference between full Subtitle C and Subtitle C-Minus is the facility-specific application of requirements based on potential risk from the hazardous special waste. Under the C-Minus scenario, as well as the Subtitle D-Plus scenario described below, the degree of potential risk of contaminating groundwater resources was used as a decision criterion in determining what level of protection (e.g., liner and closure cap requirements) would be

necessary to protect human health and the environment. Two facilities, those at Herculanum and Omaha, were determined to have a low potential to contaminate groundwater resources; two others, those at Boss and East Helena, were determined to have a moderate groundwater contamination potential; the fifth, at Glover, was determined to have high potential for groundwater contamination.

Under Subtitle C-minus, potentially hazardous slags can be managed in disposal wastepiles only under low groundwater risk conditions. Therefore, under Subtitle C-minus, both facilities with low groundwater contamination risk would be allowed to continue to operate their present wastepiles (i.e., a disposal wastepile at Herculanum and storage wastepiles at Omaha), after retrofitting the units with run-on/run-off and wind dispersal/dust suppression controls. The remaining three facilities cannot continue to operate their disposal wastepiles and would be required to build disposal landfills. The units are assumed to require at least a three foot liner of clay protected by a fill layer; in the case of the Glover facility with its high potential for groundwater contamination, a composite liner (i.e., clay with a synthetic liner and a protective fill layer) and leachate collection system are assumed to be required. All four facilities that dispose on-site (i.e., excluding the Omaha refinery) are required to perform groundwater monitoring. In addition, the disposal units must undergo formal closure, including a cap of crushed stone or topsoil and grass, and post-closure care must be performed (e.g., leachate collection and treatment, cap and run-on/run-off control maintenance, and continued groundwater monitoring) for a period of 30 years.

Subtitle D-Plus

As under both Subtitle C scenarios, facility operators would, under the Subtitle D-Plus scenario, be required to ensure that hazardous contaminants do not escape into the environment. Like the Subtitle C-Minus scenario, facility-specific requirements are applied to allow the level of protection to increase as the potential risk to groundwater increases. Under this scenario, unlike the Subtitle C-Minus scenario, all facilities, regardless of their risk potential for groundwater contamination, are assumed to be allowed to continue to operate disposal wastepiles. Disposal wastepiles under high and moderate groundwater contamination risk potentials must, however, be adequately lined (e.g., in situ clay is not considered adequate). As none of the three lead facilities determined to have high or moderate risk potential currently conform to this requirement, all three would rebuild disposal units, operating either disposal landfills or wastepiles, depending on the relative cost. The least cost alternative at the East Helena facility is expected to be the disposal landfill, while the disposal wastepile is the least cost alternative at the Glover and Boss facilities. The disposal landfills are assumed to require a clay liner with a protective fill layer under the moderate potential for risk found at East Helena; the new disposal wastepiles employed at Glover and Boss are assumed to be underlain by concrete. Groundwater monitoring is required at all three facilities in addition to run-on/run-off and wind dispersal/dust suppression controls; these practices must be continued through the post-closure care period.

At the Herculanum and Omaha facilities, current slag management units are acceptable because the potential for ground-water contamination is low. The wastepiles would, however, be retrofitted with run-on/run-off and wind dispersal/dust suppression controls which, as under the Subtitle C-Minus scenario, would have to be maintained through closure and the post-closure care period. Ground-water monitoring and capping at closure is assumed to not be required for management units under Subtitle D-Plus when the ground-water contamination potential is low, though wind dispersal/dust suppression controls must be maintained.

10.6.2 Cost Impact Assessment Results

Results of the cost impact analysis for the primary lead sector are presented by facility and regulatory scenario in Exhibit 10-12

(e) The above summarized these values are such that EBY reflects the compliance cost estimates reported here are broken to two significant figures. Values reported in the table are those computed by EBY's cost estimation model and are included for illustrative purposes. The data summarized and summarized.

Variable: Total:	135 620	\$7650 \$4,000	10,803 \$4,000	1,225 \$180	1,320 \$1,000	4,100 \$2,000	3,14 \$250	1,210 \$1,000	2,510 \$2,000	2,820 \$2,000
DoE Run - Heterogeneous MO DoE Run - Base MO Variable - Quartz ME Variable - Glass MO Variable - East Hetero ML	108 40 531 112 182	\$2,200 1,400 1,310 \$2,000 \$2,400	14,000 3,500 150 10,000 \$2,200	\$2,500 100 10 1,000 \$2,500	800 1,100 1,300 \$4,000 \$1,000	\$1,000 1,200 100 \$1,100 1,100	310 500 50 1,300 1,300	251 344 1,300 \$1,000 \$1,000	1,100 1,200 \$1,000 \$1,100 1,100	\$2,500 \$2,000 \$2,000 1,100 1,100
Leads	(\$ 000) Annual Total	(\$ 000) Annual	(\$ 000) Capital Total	(\$ 000) Capital Annual	(\$ 000) Capital Annual	(\$ 000) Capital Annual	(\$ 000) Capital Annual	(\$ 000) Capital Annual	(\$ 000) Capital Annual	(\$ 000) Capital Annual
Management Cost Baseline Waste										

Lead Slag from Primary Processing (e)
Compliance Cost Analysis Results for Management of
Exhibit 10-15

all five facilities are assumed to incur costs under the three regulatory scenarios. Under the Subtitle C scenario, annualized incremental regulatory compliance costs range across facilities from just over \$1.3 million to just over \$5.4 million greater than baseline; the sector-wide total is \$14.6 million over baseline. For all of the five facilities in the sector, Subtitle C compliance would imply a significant increase in slag management costs; costs at ASARCO's stand-alone lead refinery at Omaha (which ships its slag off-site for disposal) would increase by a factor of almost five, while on-site disposal costs at the four plants operating lead smelters would increase by at least 25-fold and by as much as 37-fold. Compliance-related capital expenditures are substantial at the four primary lead facilities that conduct smelting operations. New capital expenditures at the Boss facility would exceed \$3.2 million, while new waste management units at the Glover, Herculaneum, and East Helena facilities would require capital expenditures of \$10.9 million, \$14.8 million, and \$25.5 million, respectively. The majority of the prospective cost impact is attributable to the design and construction of the very large Subtitle C landfills that would be required to manage this waste. New capital expenditures (as well as new operating expenditures) at the Omaha refinery would be modest, because EPA believes that this facility would continue to ship its slag off-site for disposal, and hence would not experience the costs associated with building an on-site Subtitle C disposal unit (landfill).

Under the facility specific risk-based requirements of the Subtitle C-Minus scenario, costs of regulatory compliance are, for the sector, about half of those of the full Subtitle C scenario. Annualized compliance costs under this scenario range from about \$0.84 to \$2.9 million greater than baseline; the total compliance cost for the sector is approximately \$8.7 million over baseline. Compliance-related capital expenditures range from about \$1.5 million to more than \$11 million, excepting the Omaha refinery. The costs at the Omaha facility, with its off-site disposal needs, are virtually the same under either Subtitle C scenario as the disposal is to an off-site RCRA hazardous waste operation in either case. For the remaining four facilities that all conduct smelting operations, this less restrictive scenario results in a reduction of required capital expenditures of more than 50 percent. The primary reason for the difference in waste management cost is the fact that, while all facilities would be forced to build new environmentally protective disposal units, relaxation of the minimum technology requirements, which changes the configuration of the landfill liner, leachate collection/detection system, and (closure) cap, would substantially reduce the capital expenditures needed. In addition, the Herculaneum facility would be allowed to construct a disposal waste pile rather than a landfill, reducing new capital expenditures by a factor of seven.

Under the Subtitle D-Plus regulatory scenario, compliance-related waste management costs, about \$7.6 million over baseline, are about 88 percent of the Subtitle C-minus costs (i.e., a 12 percent savings), though the costs represent a 46 percent savings over the full Subtitle C costs. At ASARCO/Omaha, EPA assumes that the facility will construct an adequately protective land disposal unit (landfill), rather than continue to ship its refinery slag to a commercial disposal facility (disposal in a municipal or industrial solid waste landfill is assumed here to not be adequately protective of the environment). The facility would achieve a cost savings of about two percent, as compared with the Subtitle C-Minus scenario, by adopting this practice. The ASARCO/East Helena facility, with its large volume of waste sent to disposal, would build, as the least cost practice, a disposal landfill that is identical to the landfill required under Subtitle C-Minus; costs under the two scenarios are therefore identical. The other three facilities, because they recycle more and dispose less smelter slag, are assumed to build, as the least cost practice, environmentally protective disposal wastepiles, at a cost savings ranging from 16 to 34 percent, as compared to the Subtitle C-Minus disposal landfills; estimated annualized compliance costs for these facilities range from \$0.57 to \$2.0 million.

10.6.3 Financial and Economic Impact Assessment To evaluate the ability of affected facilities to bear these regulatory compliance costs, EPA conducted an impact assessment consisting of three steps. First, the Agency compared the estimated costs to several measures of the financial strength of each facility (in the form of financial impact ratios) to assess the magnitude of the financial burden that would be imposed in the absence of changes in supply, demand, or price. Next, in order to determine whether compliance costs could be distributed to (shared among) other production input and product markets, EPA conducted a qualitative evaluation of the salient market factors that affect the competitive position of domestic primary lead producers. Finally, the Agency combined the results of the first two steps to arrive at predicted ultimate compliance-related economic impacts on the lead industry. The methods and assumptions used to conduct this analysis are described in Chapter 2 and in a Appendix E-4 to this document, while detailed results are presented in Appendix E-5 (appendices are contained in Volume III).

Financial Ratio Analysis

EPA's compliance cost ratios suggest that all five primary lead operations would be potentially affected under any regulatory scenario, though impacts on the Herculanum facility would be modest under the Subtitle C-Minus and D-Plus scenarios. These financial ratio results are presented in Exhibit 10-13.

Under the Subtitle C scenario, three of the operations are expected to incur highly significant impacts; annualized compliance costs as a percentage of value added exceed twelve percent at these plants. Ratios at the remaining two plants (Glover and Herculanum) are more moderate (about nine and five percent, respectively). Impacts at the East Helena smelter are particularly extreme; costs approach 50 percent of value added and annualized capital expenditures to achieve compliance would exceed annual sustaining capital at the facility.

Impacts under the Subtitle C-Minus scenario are generally similar to those of the full Subtitle C scenario, though of somewhat lesser magnitude, with the exception of the Herculanum facility. The Herculanum smelter/refinery is assumed to be able to continue to employ a disposal wastepile under this scenario (because it poses only a low risk to ground water); costs, and therefore, impacts, are substantially lower (81 percent) than under the full Subtitle C scenario. ASARCO/Omaha has nearly identical ratio results, because off-site disposal costs are the same under the two Subtitle C scenarios.

In terms of impacts, there are no dramatic differences between the Subtitle C-Minus and Subtitle D-Plus scenarios, though, as discussed above, compliance costs would be reduced at some facilities.

Market Factor Analysis

General Competitive Position

The U.S. lead smelting and refining facilities are among the lowest cost in the world. This stems largely from the fact that the Missouri smelter ore sources are among the only significant primary lead supplies in the world. The fact that the lead is not associated with significant impurities allows for the production of a concentrate (smelter feed) with very high lead content (greater than 70 percent lead). This is far different than most lead concentrates produced by other nations, in which lead levels range from 30 to 55 percent. Concentrates with lower lead content require more flux and coke in the smelting process, and are therefore more expensive to refine.

Looking strictly at smelting and refining costs, however, yields a distorted picture of the overall economics of lead production in the United States. Most foreign primary lead facilities are operated to produce significant quantities of co-products or by-products, meaning that a substantial share of their operating revenues are derived from sales of refined zinc, silver, and/or other metals. The U.S. lead producers have

Exhibit 10-13
Significance of Regulatory Compliance Costs for
Lead Slag from Primary Processing^(a)

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
ASARCO - East Helena, MT	23.3%	49.9%	105.4%
ASARCO - Glover, MO	5.5%	8.8%	29.5%
ASARCO - Omaha, NE	3.7%	12.2%	0.5%
Doe Run - Boss, MO	11.4%	18.0%	35.0%
Doe Run - Herculaneum, MO	3.4%	5.4%	19.7%
Subtitle C-Minus			
ASARCO - East Helena, MT	12.5%	26.7%	47.0%
ASARCO - Glover, MO	4.8%	7.6%	23.6%
ASARCO - Omaha, NE	3.8%	12.3%	0.7%
Doe Run - Boss, MO	8.9%	14.2%	16.6%
Doe Run - Herculaneum, MO	0.8%	1.3%	2.8%
Subtitle D-Plus			
ASARCO - East Helena, MT	12.5%	26.7%	47.0%
ASARCO - Glover, MO	4.0%	6.3%	20.6%
ASARCO - Omaha, NE	3.7%	12.0%	13.6%
Doe Run - Boss, MO	5.8%	9.2%	20.6%
Doe Run - Herculaneum, MO	0.6%	0.9%	2.3%
CC/VOS = Compliance Costs as Percent of Sales CC/VA = Compliance Costs as Percent of Value Added IR/K = Annualized Capital Investment Requirements as Percent of Current Capital Outlays			

(a) Values reported in this table are based upon EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.

minimal by-product revenues and, accordingly, are very dependent upon lead sales for their revenues. Foreign lead facilities may smelt at a high cost but the by-product credits result in a very low allocated lead cost per pound. For this reason, the allocated cost of lead production at many foreign facilities is less than 20 cents per pound, despite total metal smelting and refining costs that range from 10 to 16 cents per pound.

In contrast, smelting and refining costs for Missouri facilities are on the order of 10 - 11 cents per pound of lead, but overall cash costs of lead metal production are in the range of 20 cents per pound. As a result, domestic producers of lead are on the upper end of the supply curve (i.e., are less cost-competitive) as compared to most foreign lead producers.

At 1989 price levels, current production costs (about 20 cents/lb.) are adequate to produce substantial profits for all of the integrated domestic lead producers. If, however, lead prices (in real terms) were to fall back to historical long-range levels, then the operating margins for domestic producers would become very small.

Potential for Compliance Cost Pass-Through

Labor Markets. There has been a considerable reduction in employment levels in the U.S. lead industry throughout the 1980s. In order to remain cost-competitive, reductions in unit costs of both labor and supplies were

necessary to avoid permanent closure of several smelter/refinery facilities. It is unlikely that there could be substantially more reductions on the labor rate side or in staffing without affecting operational efficiency.

Raw Material Supply Markets. Since the suppliers of lead smelting and refining industry are primarily company-owned lead mines, there is little opportunity to reduce the price paid for lead concentrate. Some facilities might, however, be able to reduce prices paid to independent mines for concentrates to a limited extent. Beyond a certain price level, however, those concentrates would probably be offered for sale on the world market.

Smelter/refineries not associated with mines would be at a disadvantage in attracting concentrates from foreign sources; they already have high operating costs on a competitive world basis.

Higher Prices. The U.S. lead producers have some limited flexibility in raising prices due to the 1 cent to 4 cent-per-pound cost advantage that they enjoy in shipping to certain areas in the U.S., as compared to foreign lead metal suppliers. This advantage is reflected in the fact that U.S. refined production has recovered significantly from the market downturns of the early 1980s. Domestic primary and secondary lead sources provide almost 90 percent of U.S. requirements. As a result, domestic lead processors may be able to pass through compliance costs to domestic consumers to a limited extent.

Evaluation of Cost/Economic Impacts

EPA expects that all five domestic primary lead operations would suffer significant cost and financial impacts from full Subtitle C regulation of lead slag. Regulation under the Subtitle C-Minus or D-Plus regulatory scenarios would also impose significant impacts at four of the five facilities; waste management costs at the Herculaneum smelter/refinery would not increase as dramatically, due to the environmental characteristics of its location. Given significant waste management cost increases and a very limited potential for compliance cost pass-through, EPA believes that stringent regulation of lead slag as a hazardous waste under RCRA Subtitle C could pose a serious threat to the continued viability of much of the domestic primary lead processing industry.

Estimated compliance costs represent significant portions of the value of shipments and the value added by lead processing operations, and presumably, would at least periodically exceed the operating margins of the lead processors. Initial capital investment requirements exceed \$8 million at two facilities under both Subtitle C scenarios and exceed \$1.5 million at all smelters under either Subtitle C scenario. EPA believes that some of these facilities might choose not to make these capital investments, and that those that did upgrade their waste management practices might experience difficulty in obtaining external financing.

At the largest primary processing facility, Doe Run's integrated Herculaneum operation, impacts associated with Subtitle C-Minus or D-Plus would be much less than at the other three smelter operations, and would probably not threaten its continued operation. Additionally, should the operators of the ASARCO/Omaha refinery opt to ship their refinery slag to a smelter for recycling rather than to disposal (current practice at the three integrated lead processing facilities), then it would not incur significant impacts if lead slag were to be removed from the Mining Waste Exclusion. Indirect impacts to the Omaha facility would be incurred, however, if the East Helena smelter, the refinery's primary source of unrefined lead bullion, should curtail or suspend operations. In that event, the Omaha facility would either discontinue operations or become a secondary producer.

Even under the relaxed waste management standards of the Subtitle C-Minus or D-Plus scenarios, at least three primary lead processors would probably incur highly significant cost and financial impacts. Unless recycling or reprocessing of the slag could reduce the quantities to be disposed in waste management units, these impacts could threaten the continued viability of these facilities, even in the absence of a decision to remove lead slag from the Mining Waste Exclusion. The Boss facility is already on standby status and new regulatory compliance costs would likely force Doe Run to discontinue operations (even in the absence of new regulations, the U.S. Bureau of Mines estimates that the long-term capacity utilization of this facility is only 20 percent). Closure of ASARCO's East Helena or Glover facilities, on the other hand, which are expected to operate at 80 and 100 percent of capacity, respectively, would have

significant repercussions not only on the facilities themselves, but potentially on domestic extraction and beneficiation operations supplying the plants. A portion of the reduced smelting and refining capacity would likely be picked up by secondary processors recycling scrap lead. Although current prices for lead are relatively high, and the domestic producers are operating at a profit, the long-term outlook for primary lead processors is uncertain.

10.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) the potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of lead slag is relatively high compared to the other mineral processing wastes studied in this report. Numerous slag samples analyzed with the EP leach test did exceed the regulatory levels. Lead was measured in EP leachate in excess of the EP regulatory level at all five facilities, in a total of 27 out of 101 samples. Cadmium concentrations exceeded the regulatory level in 7 out of 99 samples (from 2 of 5 facilities tested). Arsenic, mercury, and selenium concentrations measured in EP leachate exceeded the regulatory levels only in samples of refinery slag from the ASARCO refinery in Omaha, NE. Arsenic and selenium exceeded the regulatory levels in roughly 27 out of 94 samples, while mercury exceeded the level in 79 out of 94 samples. None of the slag samples that were analyzed using the SPLP leach test (EPA Method 1312) contained constituents in concentrations above the EP toxicity regulatory levels. In addition to these exceedances of the EP toxicity regulatory levels, lead slag contains 12 constituents in concentrations that exceed the risk screening criteria used in this analysis by more than a factor of 10. All of these factors lead EPA to conclude that lead slag, especially refinery slag, could pose a significant risk if mismanaged.

Based on an examination of existing release and exposure conditions at the five active lead facilities, as well as predictive modeling, EPA concludes that management of lead slag at some sites could allow the migration of contaminants into surface water and ground water in harmful concentrations. At the Glover, East Helena, and Boss facilities, the Agency estimates that, without any run-off controls, erosion from lead slag piles could result in annual average concentrations of arsenic, lead, iron, manganese, and/or zinc in nearby creeks that exceed human health and ecological protection criteria.⁵⁹ Although significant releases to ground water appear less likely at most sites because of hydrogeologic conditions, the Agency's modeling indicates that ground water within the facility boundary at Glover and East Helena could be contaminated with cobalt in excess of irrigation guidelines. Ground water on-site at the Glover facility could also be contaminated with arsenic, but the predicted contamination would cause a lifetime cancer risk of only 4×10^{-7} if ingested and is likely to remain within the facility boundary for more than 200 years. Air pathway modeling indicates that it is very unlikely that slag piles could cause harmful concentrations of contaminants at the locations of existing residences.

The documented cases of damage associated with lead slag also indicate that management of the slag could cause surface water and ground-water contamination. By collecting data from State and EPA Regional files and personnel, EPA identified documented cases of contamination at three of the five facilities. Monitoring data show that "surface water seeps" from slag piles at the Glover and East Helena facilities contain arsenic, lead, and/or cadmium in concentrations that exceed drinking water standards. Although these seeps represent largely undiluted leachate and run-off (rather than ambient surface water concentrations) and both facilities have taken steps to reduce run-off, the documented presence of the seeps and their high concentrations support the risk modeling conclusions that run-off,

⁵⁹ The Glover and Boss facilities, however, presently collect and treat fluids coming from the lead slag piles prior to discharge, making it unlikely for the predicted surface water contamination to actually occur at these sites. It is possible that the contamination could occur in the future if the run-off control systems are not maintained after closure.

if not controlled, could be an important contributor to surface water contamination. Information collected from the damage case research also suggests that the slag pile at the Boss facility could cause surface water contamination, as predicted by the risk modeling. However, the damage case data suggest more extensive ground-water contamination at the Glover, East Helena, and Boss facilities than is predicted by the modeling, possibly due to the presence of other on-site contaminant sources and additional factors not fully accounted for in the risk modeling.

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

As summarized above, current waste management practices and environmental conditions may allow contaminant migration and exposures in the future in the absence of more stringent regulation. Although all of the existing slag piles are located within 1,100 meters of a creek or river (three are within 100 meters of a water body) and four of the five facilities are located in areas with high to moderate precipitation rates, only the slag piles at the Glover and Boss facilities are equipped with storm water run-on/run-off controls. In addition, only the slag piles at the Omaha facility are equipped with a synthetic liner (made of concrete), even though releases to ground water from the slag piles at three other sites are considered possible based on a review of the site conditions, risk modeling results, and damage case findings. Therefore, contaminant migration during the operating life of most units appears possible, and these releases could persist after closure if the units are not closed properly. Considering the intrinsic hazard of the waste, these releases could conceivably cause ecological impacts, as well as significant human exposures if nearby ground or surface water is used.

Because of overall market conditions, EPA believes that the prospect of additional primary lead smelting/refining facilities commencing operation in the U.S. is unlikely. Therefore, EPA believes that it is unlikely that new lead facilities will start up in the future having management practices and environmental conditions different than those considered here. However, the refinery slag from the Omaha facility -- which contains by far the greatest concentration of contaminants of the lead slag analyzed -- is shipped off-site for disposal. EPA has no information on the management controls and environmental conditions at this off-site location, which could be conducive to releases and associated risks. Furthermore, although the slag is presently not used off-site, it has been in the past and conceivably could be again in the future. Any off-site uses, if not properly controlled, could also result in damages in the future.

EPA concludes that current State regulation of lead slag management practices is notably limited in scope. The five existing facilities are located in Montana, Nebraska, and Missouri (three facilities), all of which exclude mineral processing wastes from hazardous waste regulation. Montana classifies lead slag as solid waste, but excludes slag generated at the East Helena facility from solid waste regulatory requirements because the slag is managed on-site. Although not studied in detail for this report, a brief review of Nebraska regulations suggests that this State also does not regulate lead slag as a solid waste. Historically, Missouri has not addressed lead slag under its solid waste regulations. Missouri recently passed a Metallic Minerals Waste Management Act, however, that will apply to generators of lead slag. Until the State drafts regulations to implement this Act and issues permits, it is not clear how comprehensively or stringently Missouri will regulate lead slag. Missouri does require owners/operators to obtain NPDES permits for storm water discharges, and thus to install run-on/run-off controls. As discussed above, however, only the slag pile at the Glover facility is currently equipped with such controls. Montana does not require storm water run-on/run-off controls for lead slag piles, and neither Missouri nor Montana require measures to control fugitive dust emissions from lead slag piles (though based on the risk modeling results, windblown dust from the existing slag piles does not appear to pose a significant inhalation risk). Given these limited state controls, it is questionable if human health and environmental protection will be ensured in the future in the absence of additional Federal regulation.

Costs and Impacts of Subtitle C Regulation

EPA has evaluated the costs and associated impacts of regulating this waste as a hazardous waste under RCRA Subtitle C. EPA's waste characterization data indicate that lead slag may exhibit the hazardous waste characteristic of EP toxicity at all of the five active facilities. Costs of regulatory compliance under the full Subtitle C scenario exceed \$1 million annually at all facilities; these costs would impose potentially significant economic impacts on the operators of

all five plants. Application of the more flexible Subtitle C-Minus regulatory scenario would result in compliance costs that are approximately 40 percent lower. Costs under the Subtitle C-Minus and Subtitle D-Plus scenarios are similar (or identical) at three of the five facilities, because adequately protective waste management unit design and operating standards are essentially the same under both scenarios, given the nature of the waste and the environmental settings in which it is currently managed.

These costs would comprise a significant fraction of the value of shipments of and value added by primary lead smelting/refining operations. ASARCO's East Helena smelter and Omaha refinery, and Doe Run's Boss smelter/refinery would suffer particularly pronounced impacts; compliance costs as a percentage of value of shipments approach or exceed ten percent at each of these plants, even under the Subtitle D-Plus regulatory scenario. EPA's economic impact analysis suggests that although the current price of lead is relatively high and domestic producers are operating at a profit, the long-term outlook for the domestic primary lead industry is uncertain. Demand for production of refined lead from virgin sources has been falling in recent years relative to production of secondary lead by recycling of lead-containing products (e.g., automotive batteries). Therefore, EPA believes that the operators of primary lead plants could pass through a portion of any regulatory compliance costs that they might incur to product consumers, but that it is improbable that prices could be raised to a level adequate to completely off-set regulatory compliance costs.

Finally, it is worthy of note that these impacts might occur even in the absence of a decision to remove lead slag from the Mining Waste Exclusion, because adequately protective waste management standards under a Subtitle D program may require the construction of new waste management units, implying significant new capital expenditures.

Finally, EPA believes that incentives for recycling or utilization of lead slag would be mixed if a change in the regulatory status of this waste were to occur. Recycling is currently the predominant management practice that is applied to lead slag. It is possible that tighter regulatory controls on the management of primary lead slag might serve to promote even greater recycling and on-site utilization than has occurred in the recent past, e.g., through slag fuming for zinc oxide recovery. Utilization of lead slag in construction and other off-site applications has been reported, but is not widely practiced at present, primarily due to the availability of substitutes and concerns about environmental impacts arising from such use. It is likely that removing lead slag from the Mining Waste Exclusion and thereby subjecting it to regulation as a hazardous waste would, in practical terms, eliminate the use of this material in construction applications.

Exhibit 10-12
Compliance Cost Analysis Results for Management of
Lead Slag from Primary Processing^(a)

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total (\$ 000)	Annual Total (\$ 000)	Total Capital (\$ 000)	Annual Capital (\$ 000)	Annual Total (\$ 000)	Total Capital (\$ 000)	Annual Capital (\$ 000)	Annual Total (\$ 000)	Total Capital (\$ 000)	Annual Capital (\$ 000)
Asarco - East Helena MT	165	5,402	25,546	3,812	2,895	11,395	1,700	2,895	11,395	1,700
Asarco - Glover MO	115	2,805	10,893	1,625	2,416	8,711	1,300	2,016	7,617	1,137
Asarco - Omaha NE	231	1,379	129	19	1,391	191	29	1,354	3,675	548
Doe Run - Boss MO	40	1,464	3,281	490	1,148	1,554	232	744	1,936	289
Doe Run - Herculanum MO	108	3,549	14,836	2,214	839	2,075	310	571	1,754	262
Total:	659	14,599	54,685	8,160	8,689	23,926	3,570	7,580	26,377	3,936
Average:	132	2,920	10,937	1,632	1,738	4,785	714	1,516	5,275	787

(a) Values reported in this table are those computed by EPA's cost estimating model, and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.